ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 62. No. 22. 220 Broadway, New York, November 25, 1909.

TABLE OF CONTENTS.

	Page.
LEADING ARTICLES:	
Extracts from the Annual Report of the Isthmian Canal Commission (illustrated)	565
The Western Railroad Association; A Mutual Bureau for Protection of Railway Companies Against Patent Infringement Suits	568
The Design of the Broadway or Sparkman St. Bridge, Nashville, Tenn. (illustrated); Howard M. Jones, M. Am. Soc. C. E.	570
Huge Venturi Meters Registering 625 Cu. Ft. per Second, Divi Island Pumping Plant, Madras, India (illustrated)	577
Notable Record of a Plant Pumping with Diesel Engines, Divi Island Station, Madras, India (illustrated)	578
Experiments on Conveying Concrete Through Pipes Under Air Pressure (illustrated); J. W. Buzzell, Assoc. M. Am. Soc. C. E., and William H. Larkin, Jr., M. Am. Soc. M. E.	579
Lining and Grouting a French Railway Tunnel in Water-Bearing Material (illustrated)	580
The Pumping of Cement Grout Into Masonry on the Metropolitan Railway, Paris (illustrated)	581
Care in the Construction of Vitrified Brick Streets (illustrated); Will P Blair	586
Tables for the Determination of Earth Pressures on Retaining Walls (illustrated); C. K. Mohler	588
Annual Meeting of the Society of Naval Architects and Marine Engineers	589
Annual Conventions of the National Municipal League and the American Civic Association	591
EDITORIAL	583
The Necessity for Two Openings to Mines—Laying High-Quality Concrete Under Water—A Steam Turbine Locomotive—The Unreliability of Small Size Tests for Reinforced-Concrete Trusses—New Zealand Builds the Largest Masonry Arch—The Abuses in Connection with Land Condemnation in New York—Permissible Explosives for Coal Mines—Simplification of Railway Rates.	
The Panama Canal: A Work Worthy of National Pride	584
LETTERS TO THE EDITOR	585
Who Is the "Engineer" in This Specification? Michael O'Sullivan—Is the Saving by Metering Water Offset by the Increased Cost of Plumbing Repairs? S. D. Dodge—Advertising for Bids for Professional Services; Burns & McDonnell.	
ENGINEERING NEWS OF THE WEEK	594
PERSONALS	595
ENGINEERING SOCIETIES	595

Extracts from the Annual Report of the Isthmian Canal Commission.

Hon. J. M. Dickinson,
Secretary of War, Washington, D. C.

SIR: I have the honor to submit the annual report for the Isthmian Canal Commission for the fiscal year ended June 30, 1909.

Organization.

A complete reorganization of the work was inaugurated on July 1, 1908. The subdepartments of the department of construction and engineering were abolished and three construction divisions substituted—the Atlantic division extending from deep water in the Caribbean to include Gatun locks and dam, the Central division extending from Gatun dam to Pedro Miguel locks, and the Pacific division from Pedro Miguel locks to deep water in the Pacific.

With the reorganization the work in the office of the chief engineer, who is the head of the department of construction and engineering, was subdivided into three divisions. The first is under Lieut.-Col. H. F. Hodges, who, as assistant chief engineer, has charge of the design of the locks and dams and their appurtenances; he also considers and reports upon all questions of a civil-engineering nature that may arise in the progress of the work. The second is under Mr. H. H. Rousseau, U. S. Navy, who has charge of all mechanical questions that may arise, looks after expenditures, the preparation of estimates, and supervises cost-keeping. The third is under Mr. C. M. Saville, who, as assistant engineer, has charge of hydrographic and meteorological work, such general surveys as are not embraced within the limits of any of the construction divisions, and makes such special investigations as may be assigned to him.

During the year the designs for the upper locks at Gatun and the locks at Pedro Miguel were finished. The locks in pairs, separated by a wall 60 ft. thick, are 110 ft. in width, with 1,000 ft. usable lengths.

After study and investigation of various forms of gates, the double leaf, double sheathed, straight, mitering gates were adopted as being the most economical in construction, operation, and maintenance. In all plans for the canal it has been accepted as a fundamental feature of design that at each flight of locks there must always be two barriers separating the high level from the level next below. After careful study of the horizontal rolling gate as the barrier it was abandoned because of the great cost and weight, and another set of mitering gates was substituted with a chain barrier controlled by capstans in the wall. As over 95% of the vessels of the world are less than 600 ft. long, intermediate gates have been introduced as a feature of the finished design, dividing the lock chambers into two parts suited to vessels of 550 and 350 ft. in length, respectively; these are also protected by a chain barrier.

Guide piers are to be constructed both up and down stream from the locks against which vessels will tie before entering the locks. Designs for electric towing machines are being prepared, which in all probability will be used for towing vessels into and controlling them throughout the passage of the locks.

Atlantic Division.

The work of this construction division is in charge of Maj. W. L. Sibert, Corps of Engineers, U. S. Army, as division engineer.

Gatun locks.—The character of the foundations for the locks was fully explained in the last annual report. The various materials have since been exposed and tested by trial loads which show conclusively that the soft sandstone has sufficient resistance to bear safely the greatest loads that will be brought on it by the structures. It has also been decided to construct curtain walls to stop any underflow; these will extend across the lock under the sill of the emergency dam and downstream outside the lock walls to the sills of the intermediate gates. The holding qualities of the soft sandstone were also tested by the application of power to pull out French rails anchored into it by concrete. As a result it was decided to give a thickness of 13 ft. to the concrete floor of the locks between the upper miter sill and the sill for the intermediate gates, and to use old French rails on hand for the anchorages. The work of placing the rails is well under way. As an additional precaution a system of sumps under the floors with telltales in the walls will be provided. In the forebay between the sill for the emergency dam and the first miter sill of the lock a 20-ft. thickness of concrete has been adopted for the floor.

The plant for the construction of the lock is practically installed and ready for operation. The sand, stone, and cement will be brought in barges up the French canal to unloading docks built on either side of the East Diversion, to which a channel has been dredged. The cement shed, having a capacity of 100,000 bbls., occupies the east dock; it is provided with electric cranes for unloading and storing the cement. Barges with sand and stone tie up to the west dock and are unloaded by one single and two duplex cableways, supported by steel towers 800 ft. apart, which transport the materials to stock piles capable of storing about 200,000 cu. yds. of stone and 100,000 cu. yds. of sand.

An electric railway passes under the cement shed, thence through tunnels under the stock piles to the concrete mixers on the west side of the lock site. Automatic cars travel this road, receiving en route sufficient cement, sand, and stone for a 2-yd. batch of concrete. The mixers, of the cubical type, are eight in number, and each dumps its product into a bucket on a car, two of which are taken by an electric locomotive to four duplex cableways, 800 ft. across, which span the locks, and which in turn take the buckets and deliver the contents where desired. The forms are to be of steel.

The entire plant is operated by electricity with current supplied by 3-phase, 25-cycle, alternating generators, each of 1,500-KW. capacity, located in a temporary power-house during construction, to be eventually moved to a site on the spillway.

Gatun dam.—As noted in the annual report, 1907, the dam was to be constructed of two rock piles 1,200 ft. apart and made of spoil from Culebra cut, the lock site and the excavation for the spillway, between which

GATUN LOCK SITE FROM THE EAST, SHOWING LIDGERWOOD CABLEWAYS AND CONCRETE WORK BEGUN.

piles selected material was to be deposited hydraulically, forming the impervious part of the dam.

During the year the south rock fill east of Spillway Hill was raised to elevation 58, and from this elevation material was so dumped on the upstream side as to secure the proper slope. West of the spillway, spoil from various sources was dumped east of the West Diversion through which the Chagres River now discharges up to reference 24. The embankment inside the north rock toe was carried up to +35 east of the spillway, and at the close of the year three 20-in. suction dredges were depositing material over the area between the rock piles, which had been cleared of all vegetation, and trenched so as to make a proper bond; this fill has reached an average elevation of +16. A total of 2,501,372 cu. yds. of material were placed in the dam during the year.

The excavation through Spillway Hill is practically completed and the concrete floor laid below the area that is to be occupied by the dam which is to support the regulating works. Arrangements will be made so that as soon as the side walls and floor are finished, and provisions completed for the construction of the concrete dam, the earth dam can be carried across the West Diversion. This will cause the river to discharge through the spillway channel. As the reference of the floor will be held at +10, the closing of the diversion will be the first step toward the formation of the Gatun Lake, the rising level of which will be subject to control by means of culverts with valves placed at a low level in the spillway dam.

The Mindi Hills, through which the line of the canal passes, reached an elevation of 50 to 60 ft. between the limits of the completed channel, and, as previously reported, the excavation for the canal was started by steam shovels. Because the French canal is so close to the area covered by the cutting, and the Mindi River within a few hundred yards, it was anticipated that, when

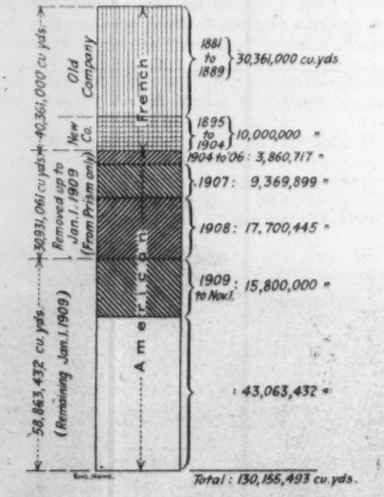


Diagram Showing Progress in Excavation of Central Division, Panama Canal.

the shovels reached sea level, excavation in the dry would give way to the dredges. It was found, however, that, notwithstanding the seamy character of the rock, the overlying clay was a good protection against seepage, and that a small dike of natural soil was ample to keep out water from the French canal. As the material can be removed more cheaply by the shovels than by dredging, excavation in the dry was continued. One shovel is now at 32 ft. below sea level, or 9 ft. above the completed bottom grade for this portion. The total amount removed during the year was 615,146 cu. yds., of which 448,287 cu. yds. were rock.

The dredging fleet, consisting of one sea-going suction dredge, two 5-yd. dipper dredges and three French ladder dredges, worked on the section between Mindi and deep water in the Caribbean, removing from the projected channel a total of 6,039,934 cu. yds., of which 427,005 cu. yds. were rock. Rock is removed after blasting. To effect this, holes averaging 15 ft. apart are made by churn drills to a depth of 50 ft. below sea level, loaded with dynamite and fired. At the close of the year nearly 3 miles of the channel from deep water (41 ft. at mean tide) were completed.

Central Division.

The work of this construction division is in charge of Lieut.-Col. D. D. Gaillard, Corps of Engineers, U. S. Army, as division engineer.

Culebra section.—The Culebra section of the division extends from the Chagres River in the vicinity of Gamboa to Pedro Miguel. The original plan contemplated a channel 300 ft. wide at the bottom, except for the portion between Las Cascadas and Paraiso where the width was fixed at 200 ft. Under date of Oct. 23, 1908, the President of the United States directed the widening of this portion of the canal, so that the minimum bottom width throughout is now to be 300 ft. The widening was ordered at a propitious time, as the material could be removed much more expeditiously and economically during the last dry season than at any subsequent period. The widening of the top areas sufficiently to secure the required bottom with is practically completed.

The difficulties in the execution of the work result from the excessive rainfall. Work on the Obispo Diversion, caring for the drainage on the east side, was completed on June 1, 1909. The cutting of the diversion necessitated the excavation of about 1,132,000 cu. yds. of material, about two-fifths of which was rock, and the construction of several dikes aggregating about 1½ miles in length.

The total amount excavated from the canal prism during the year amounted to 18,442,624 cu. yds. place measurement, of which 12,291,472 cu. yds. were of rock. At the close of the fiscal year 43,574,954 cu. yds. remained to be removed in order to complete this portion of the canal.

Material hauled and dumped at Balboa is serving a useful purpose. It was utilized in filling to the east of the Panama Railroad wharves, 145 acres of ground having been reclaimed in this way, and also in building a breakwater toward Naos Island. The object of the breakwater is to cut off silt-bearing currents approaching or crossing the excavated channel in the Pacific, thereby reducing the cost of maintenance. It is extended out approximately 2 miles, and upwards of 3,000,000 cu. yds. of material were deposited from the trestle constructed for the purpose. One mile remains for completion. Considerable difficulty is experienced in maintaining the trestle at the crossing of the old French channel, but this is gradually being overcome.

The slides continue to be a source of annoyance. The Cucaracha slide, originally about 800 ft. in length and covering an area of about 6 acres, has extended northward until it joins one just south of Gold Hill. The resulting slide measures 2,700 ft. along the cut, involving an area of about 27 acres. The total amount already removed aggregated for the year 670,017 cu. yds., and it is estimated that 700,000 cu. yds. of material are still in motion, all of which will be removed as it reaches the edge of the cut. The French attempted an elaborate system of drainage without any beneficial effects.

In addition to the Cucaracha slide the next largest is at the village of New Culebra, where the French dumped material which was well removed from the prism that was projected at the time, but a part of which falls within the prism of the canal under the revised project. It is estimated that 125,000 cu. yds. are in motion and will have to be removed. Slides have also developed at old Culebra; on the east bank of the canal opposite White House Yard, and at Paraiso, together with three or four smaller ones resulting from the widening of the canal. During the year 884,530 cu. yds. were removed from all the slides, and it is estimated that 1,000,000 cu. yds. are still in motion.

Considering the amount of explosives used, the number of accidents is relatively small, but the casualties large, because of the number of men concentrated in a relatively restricted area. Changes have from time to time been made in the handling of explosives and the methods of exploding, materially reducing the accidents. Experiments were made to investigate the best method of firing the charges, and resulted in the use of current supplied by generators furnishing electric light along the canal, and in firing by fuses connected in parallel. This has practically eliminated the danger which formerly existed due to unexploded charges found by the steam shovels.

Pacific Division.

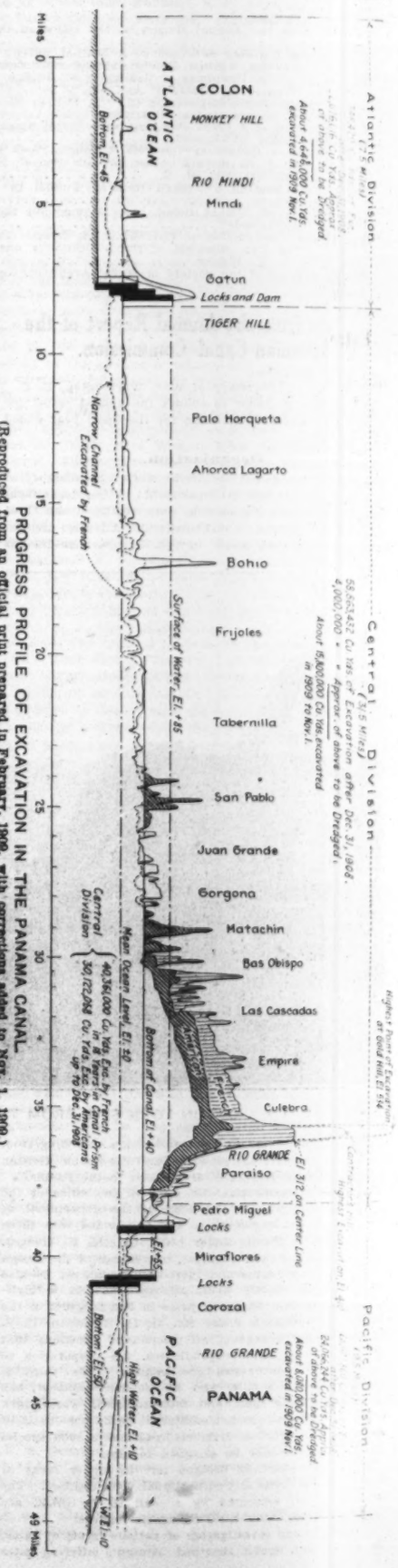
The work of this division is in charge of Mr. S. B. Williamson, as division engineer.

Pedro Miguel.—The locks are founded on durable rock of ample strength, as determined by tests, to bear safely the maximum loads that will be brought upon it, and there are no underlying water-bearing strata. The character of rock is of such a quality that a portion of it will be left in place under the central culvert, to form part of the separating wall between the lock chambers; this core will be faced with concrete. The lateral culverts will be built in trenches, and the lock floors connecting them will be 1 ft. thick. Excavation was continued during the year; the total amount removed being 715,726 cu. yds., of which 167,061 cu. yds. were used in constructing the rock toes of the dam. The work done results in the completion of the west lock chamber to grade, and of the east lock chamber, excepting about 45,000 cu. yds. which are still to be removed.

Miraflores.—The excavation for the lock site was continued by steam shovels in the upper locks, and by a suction dredge which had cut its way through to the lower locks. The total amount removed was 1,147,527 cu. yds., or about half the total estimated quantity. Of this amount 307,060 cu. yds. were placed in the toes of the dam, and 239,400 cu. yds. were used in making fills necessary for construction purposes.

The construction plant for the locks is under contract, but not yet delivered. It will consist of [illegible] cranes and four chamber cranes; the latter [illegible] on tracks in the lock chambers, removing [illegible] the forms, which will be of wood of the cant[illegible] and laying the concrete. The former, or b[illegible] will operate at Miraflores from the berms.

PROGRESS PROFILE OF EXCAVATION IN THE PANAMA CANAL.
(Reproduced from an official print prepared in February, 1909, with corrections added to Nov. 1, 1909.)



adjacent to the side walls. As here employed, they will consist of metal towers with fixed cantilevers on one side operating over storage piles parallel to the lock site, and with booms having a slight movement in a vertical plane on the other side of the towers. The materials will be transferred to concrete mixers of 2 yds. capacity located on the towers, but the concrete will be handled by the booms to the side walls, or the batches transferred to the chamber cranes and laid in the central wall. At Pedro Miguel the berm cranes can not operate in the same way, and will be modified so as to have fixed cantilevers on either side of the towers, the fixed cantilevers from two of the cranes being transferred to the other two. The two resulting cranes will operate on tracks in the level above the locks over the storage piles. The

Cross-Section of Culebra Cut at Bas Obispo.
(From "Canal Record," Oct. 27.)

mixed concrete will be taken from the mixers on the towers by cars to the lock pit and placed in the central and side walls by the chamber cranes.

To secure the necessary width and depth of channel between Pedro Miguel and Miraflores, 1,279,600 cu. yds. of material, of which 63,600 cu. yds. are of rock, must be excavated. The material still to be removed between Miraflores and deep water in the Pacific amounts to 13,000,900 cu. yds. of loam, and 1,725,000 cu. yds. of rock. Because of the tidal oscillations, and the difficulties that always arise in removing rock under water, it has been decided to remove all rock between the locks, and for about 2 miles below Miraflores locks, in the dry. To accomplish this, it is proposed to place a temporary dam about 2 miles below Miraflores locks to remove the overlying soil by an outfit of sluicing and dredging pumps, and to excavate the rock below by steam shovels in the dry. This will leave below the temporary dam about 3,600,000 cu. yds. of loam, and 123,000 cu. yds. of rock, which will be removed by dredging and by subaqueous blasting and rock breaking.

GATUN SPILLWAY FLOOR AND WALL FROM THE LOWER END.

River Hydraulics, Meteorology and Surveys.

Hydraulic data of the Chagres River above Bohio are quite complete and cover a period of 16 years. The flow during the dry season of 1908 was lower than any of record, the discharge at Bohio of 586 cu. ft. per sec. in March, 1908, being the lowest. The dry season of 1909, on the other hand, gave a discharge which was notably large, and between Jan. 27 and Feb. 1 the largest freshet since the flood of 1906 occurred. First-class gaging stations are established at Alhajuela, Bohio, Gatun River, Trinidad River, and Gatun; and river stations at Gamboa and Vigia. By the maintenance of stations at Vigia and Alhajuela, three to eight hours' notice can be given of an approaching flood.

Three first-class meteorological stations are in operation; one each at Ancon, Culebra and Cristobal, and at 22 localities rainfall stations are established. Evaporation stations are located at Rio Grande Reservoir and at Brazos Brook Reservoir. Data are also obtained at Cristobal and Ancon by means of tanks exposed to all atmospheric conditions, except the direct rays of the sun, and rainfall.

A seismograph station has been completed and the instruments installed at Ancon. The tremors that have been recorded thus far are of no greater frequency or magnitude than occur at Washington, D. C.

A general survey of the Chagres River was begun in order to determine more accurately its drainage area, and to secure such other information as is necessary to determine the run-off in the country tributary to the Chagres. The field work is practically completed.

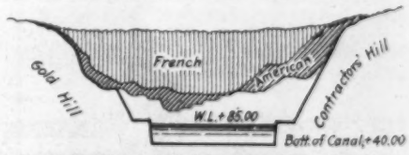
Quartermaster's Department.

A steady increase of the unskilled labor force continued until it reached its maximum on April 28, when the reports show a total of 33,699 men actually working for the commission and the Panama Railroad, the largest force of record.

One of the difficulties in the prosecution of the work is met with in procuring the necessary supplies promptly, on account of the distance from available markets and the limited transportation facilities to the Isthmus. Every effort has been made to simplify the system formerly in vogue and to forestall needs. To lessen the large number of United States requisitions sent at various times, annual estimates are now prepared covering the most important staples used in construction work, and yearly contracts have been let on these estimates. Specifications have been standardized as much as possible. The total value of material received during the year amounted to $9,600,000, and stocks on hand June 30 totaled $3,000,000.

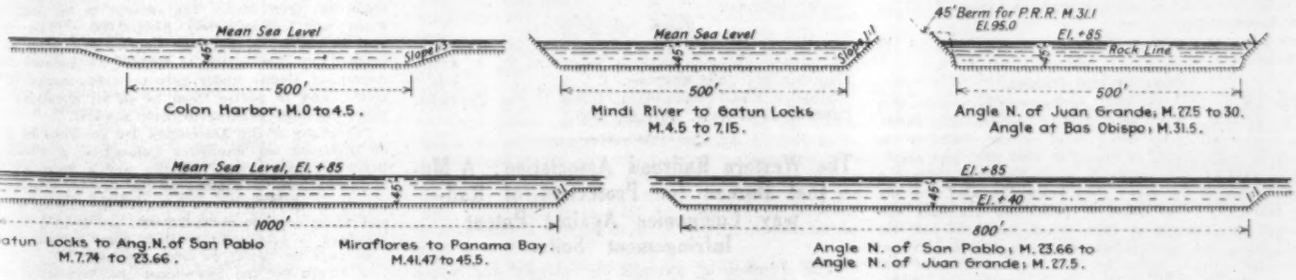
Commissary and Subsistence.

Effective July 16, 1908, the commissary belonging to and formerly operated by the Panama R. R. Co. was

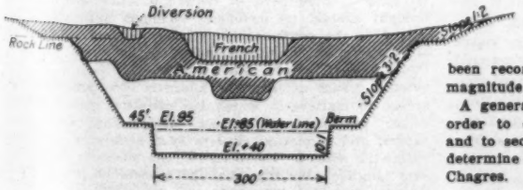


Cross-Section of Culebra Cut Near Culebra.
(From "Canal Record," Oct. 27.)

transferred to the charge of the subsistence officer of the commission, and managed in conjunction with the hotels, messes, and kitchens. The sales during the fiscal year amounted to $4,841,647.09. It is of no expense to the commission; but it is operated at a profit to the Panama Railroad, surcharges being added to the stuffs handled transferred to the charge of the subsistence officer of the commission, and managed in conjunction with the hotels, messes, and kitchens. The sales during the fiscal year amounted to $4,841,647.09. It is of no expense to the commission; but it is operated at a profit to the Panama Railroad, surcharges being added to the stuffs handled



CROSS-SECTIONS OF CHANNEL OF PANAMA CANAL AT VARIOUS POINTS.



Typical Cross Section of "Culebra Cut"
Bas Obispo M.31.5 to Pedro Miguel M.39.6.
(Jan. 1, 1909.)

Quartermaster's Department.

A steady increase of the unskilled labor force continued until it reached its maximum on April 28, when the reports show a total of 33,699 men actually working for the commission and the Panama Railroad, the largest force of record.

One of the difficulties in the prosecution of the work is met with in procuring the necessary supplies promptly, on account of the distance from available markets and sufficient to pay off the expense incurred by the railroad company for the erection of buildings and the various plants and to cover freight and handling charges along the line. New commissary buildings were constructed by the commission at Gatun and Porto Bello.

Hotels, messes, and kitchens are operated for the comfort and convenience of the employees from Palo Seco to Nombre de Dios wherever required by the necessities of construction. There are, in addition to the Tivoli Hotel, 17 hotels, 19 messes, and 21 kitchens, providing food for 7,700 people. The Tivoli Hotel shows a profit for the year; the operation of the line hotels shows a loss, the messes and kitchens a profit. The subsistence feature of the commission is self-supporting, after making allowances to the various hotels and kitchens similar to those made to married employees in the form of equipment.

Department of Sanitation.

The health conditions on the Isthmus are reported by the chief sanitary officer as showing an improvement over the preceding year. The total number of admissions of employees to hospitals and sick camps, including those sick in quarters, amounted to 46,194, representing for the year 23.49 as the number of men sick daily out of every thousand names on the pay rolls, as against 23.85 for the preceding year. The number of deaths was 530, and assuming that the average number of names on the pay-rolls for the various months during the year amounted to 44,261, the number of deaths would be equivalent to a death rate of 11.97 per thousand, as against 18.32 for the preceding year.

No cases of plague or yellow fever originated on the Isthmus.

Cost of the Canal.

The act of June 28, 1902, authorized the construction of the canal and made provisions for the necessary funds, the amount stipulated being based on the report of the board of engineers in its report of 1899-1901, and aggregating $144,233,358, including sanitation and police. A modification of the plans then submitted was made by the minority of the board of consulting engineers and adopted by Congress in 1906, which fixed the cost for engineering and construction, exclusive of the purchase price, the cost of sanitation and civil government and the interest, at $139,705,200. In the preparation of this estimate, the same unit prices were assumed as were adopted by the board of 1899-1901. In the interval, however, wages had increased, and the cost of materials and manufactured articles had risen. Prosperous conditions in the United States, combined with the unsavory reputation that the Isthmus had regarding its healthfulness, made it necessary, in order to secure labor, to increase the wage scales from 30 to 60% over those paid in the United States for similar classes of work. Certain gratuities as additional inducements were also offered, which in the main have since been continued. Moreover, the provisions of the eight-hour law were made applicable to the Isthmus.

The unit prices were therefore materially increased. Various changes had also been made in the adopted plan, increasing the quantity of work to be done. In addition, more detailed surveys and plans than were originally available had been made, and the work had progressed sufficiently to give reliable data relative to unit costs. This enabled a revised estimate to be prepared and submitted at a hearing before the Committee on Appropriations of the House of Representatives in February, 1909.

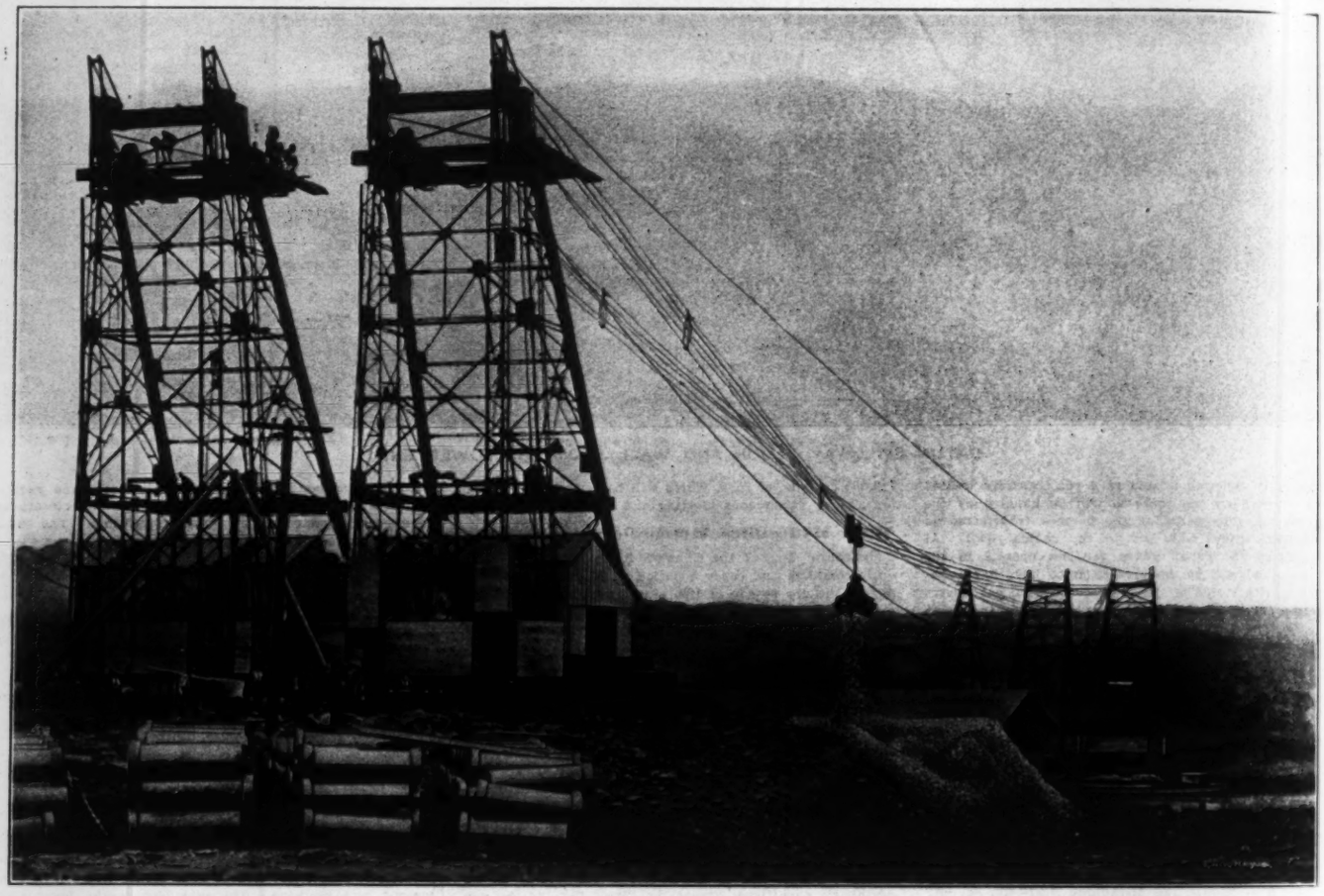
This estimate shows that nearly 50% more work is necessary in order to complete the canal than was contemplated by the original estimate and that the unit prices, due to labor conditions, cost of materials, and gratuities given the employees, have been increased about 20%. The estimate, as prepared, shows that the total cost of engineering and construction alone sums up to $297,786,000; to which, if the purchase price and the estimated cost of sanitation and civil government be added, there results the sum of $375,201,000 as the total cost of the canal.

Respectfully submitted,

Geo. W. Goethals,

Lieutenant-Colonel, Corps of Engineers, U. S. Army, Chairman and Chief Engineer.

Isthmian Canal Commission, Office of the Chairman, Culebra, Canal Zone, Aug. 20, 1909.



LIDGERWOOD CABLEWAYS TRANSFERRING CRUSHED STONE FROM BARGES TO STOCK PILE.

The Western Railroad Association: A Mutual Bureau for Protection of Railway Companies Against Patent Infringement Suits.

The number of patents on railway appliances is so vast that to avoid being constantly involved in patent disputes and infringement suits the chief railways of the country many years ago found it necessary to establish a central bureau of advice on patents. There are two such bureaus, the Eastern Railroad Association, with headquarters in Washington, D. C., and the Western Railroad Association, with headquarters at Chicago, Ill. Their functions were well described in a paper read recently before the Western Railway Club by Mr. George S. Payson, General Counsel of the Western Railroad Association, in which he dealt specifically with his own organization.

The Western Railroad Association comprises practically all of the large western, southwestern and northwestern railroads; and the New York Central Lines having their terminals in Chicago; the Erie; the Bessemer & Lake Erie; the Hocking Valley; the Grand Trunk; and the Nashville, Chattanooga & St. Louis. The dev... which may be used by our members are found in pra... lly all of the classes of patents issued, presenting ... et field for inquiry. We are open to suit anywhere ... at all times, except in the southeastern portion of ... United States.

The Association dates from some time in 18... nd was brought about by the fact that suits were th... nding under the Tanner Brake patent. Judgments ... been rendered against several roads and there was ... gree-ment that if these judgments were finally sustained they should be used as a basis for calculating damag s against roads not then sued. The amount to be paid in this event was approximately $70,000,000. [The railways won in the U. S. Supreme Court.—Ed.] The railroads formed this Association to protect its members against unfounded claims under patents, trade-marks or copyrights, and to advise them as to all questions arising under the laws relating to these subjects.

The affairs of the Association are governed by a Board of Directors, an Executive Committee, a President, a General Counsel and Treasurer, and a Secretary. Most of the business is handled by the General Counsel. The expenses, which have run from $20,000 to $35,000 a year, and which average about $29,000, are divided among the members in proportion to their gross earnings, so that each pays its share, no more, no less.

In return for the assessment the Association defends all patent, trade-mark or copyright suits that may be brought against its members; conducts negotiations involved in the settlement of claims; renders opinions on all matters of interest included in the above subjects; issues annual reports; sends out monthly lists of expired patents; issues at irregular intervals circulars with reference to matters in which our members may be interested; passes upon licenses, assignments and other papers, and generally, renders such assistance as it can within its sphere. Furthermore, the members derive the very tangible advantage that the Association tends to discourage frivolous law-suits.

Any member is entitled, without any payment beyond its regular assessment, to opinions upon all matters pertaining to patents, trade-marks or copyrights in which it may be interested. It is only necessary in order to obtain such an opinion that a request be made of me accompanied by full information.

Such requests, from practical necessity and in accordance with our rules, should be accompanied by duplicate prints of the device involved and a full description.

While fairly familiar with mechanical drawings by reason of a technical education and sixteen years' experience in this office, I often find that a drawing, clear to the man who made it, because he is familiar with the device, is not clear to me because I have never seen the device. Hence the necessity for a description, which should not only include the apparently important points, but the minor points as well.

At this day, when nearly a million patents have been issued, one rarely comes out involving a fundamental principle; they are mostly on minor improvements, and therefore the minor details of a device should be particularly described, because more likely to involve infringement and more easily overlooked. The prints should be exact and full, nothing being omitted from the prints that will be in the device when used, and (just as important) nothing being added to the device when it is used that is not shown in the prints. Some years ago I passed upon a car coupler for one of our members, advising that it could be safely used. Suit was afterwards begun, but not brought to my notice, resulting in a decision in favor of the patent and against the coupler, and I was asked why I could pass a coupler which a court could hold a plain infringement. Let it be understood that I make no pretension to infallibility; though I do my best it must needs be that errors will creep in. But this particular matter seemed so clear that I failed to understand how I could be wrong until I discovered that the road was not using the device as shown in the print, but had added a feature which in the opinion of its mechanical department was not patentable. Unfortunately it was this feature which was covered by a valid patent and, the vendor of the coupler having failed, the railroad paid $7,000 as a result of a legal opinion rendered by the mechanical department.

One of my greatest difficulties arises from the addition by the mechanical departments of features which they think clearly unpatentable, to a device previously passed upon by me, without asking me about such addition. What is the value of a lawyer's opinion if a non-legal department is going to be the Court of Appeals to decide what may or may not be added to or taken from the device without asking whether such mechanical alteration may cause me to alter my opinion? Yet this is most natural. Many patents are issued which to a skillful mechanic seem ridiculous. Many of such patents get sustained and it is therefore unsafe for one not trained in patent law to attempt to say that some modification of a device which can otherwise be safely used may not lead to infringement of a valid patent.

Another point. Failure to properly use the Association has led our members into doing what they are sometimes accused of, namely, copying a patented device. For example, suppose you send me drawings of a steel car and that these drawings are not wholly complete because you omit to send figures showing what seem to you minor points, which "minor points" have been copied from some car which you have seen upon your road. Yet these minor points may be precisely what is covered by a patent, the number of patents in this particular art being enormous; one man gets a patent on a gusset plate, another on a rectangular gusset, still another on one that is hexagonal. Of course, all these patents are not valid; in fact, I think many of the claims on steel car construction are wholly invalid as being for nothing but the substitution of metal in commercial forms for wood in forms equally well known, involving mere metal carpenter work. Just the same, it is the desire of our members not to buy lawsuits. Where the copying of a device involves litigation, it is safer and also fairer to use something else, however trivial the particular patent may seem.

Nothing is more dangerous than copying a patent, relying as a defense upon earlier devices. Suppose this is done and the road is sued and asks me to defend it. The judge is bound to ask me, "Why did you copy this patent?" I reply, "Because it is invalid in view of these old devices." The judge then asks, "Why don't you use the old devices?" The only answer is that we prefer the patented device. If so, it must be because it is better than the old devices open to any one to use. If by such use we bear the strongest testimony to the utility of the device, we can hardly blame a court for holding the patent valid on account of such utility.

I want, however, to say here and now that I have never known in all my experience with the Association of any case where there has been deliberate intentional copying of a patent. There has been actual copying, undoubtedly, but this has generally come through the imitating of some device seen on some other road or on a car belonging to some other road and traveling over your lines, with the honest belief that there was nothing about the device to make it patentable. This may help you a little in the eyes of the court as proving absence of deliberate infringement, but it is an unsafe method of proceeding.

In requesting opinions, it frequently happens that a member asks whether it can safely use a device made under a certain patent. I wish to particularly call your attention to the fact that this is not the proper form of request. It almost never happens that a device covered by a patent is made exactly like such patent. Something is generally added to or taken from the device as shown in the patent, thereby raising new questions and making necessary prints showing exactly what it is you wish to use.

It often happens that a device that as first made is an infringement of some patent can—after you are told of the patent, and without impairment of efficiency—be changed, so as to be open to use without infringement, thus avoiding use of patents to which we have no right.

Another point to be remembered is that almost anything may be patented, and therefore whenever you make a device standard it is advisable to at least apply for a patent merely as a species of insurance. Unscrupulous men are continually appropriating the ideas of others and we have several times been put to great trouble and expense in cases where a man has taken out a patent upon a device invented by some one else—some railroad employee for example—and made claim or brought suit against the road using such device. In such case we must prove the theft. This is hard to do and the consequent expense might be avoided if the road made application for a patent, at far less cost than that involved in defending a suit. I do not mean that every little thing should be made the subject of a patent application, but wherever it would cause serious annoyance or expense if you were compelled to stop using some device, it is certainly worth while to apply for a patent, if only to prevent some outsider from appropriating your ideas.

So much as to opinions; I now turn to the question of litigation. Suits against our members generally are preceded by claims for settlement, although in some instances we are sued without this. If suit is brought and the Executive Committee has not previously passed upon the question, it has to do so that it may authorize me to defend the suit. Such defense is not absolutely a matter of right from membership in the Association and the Committee's judgment is asked in each case.

One of the commonest defenses against a patent is that the device said to be covered by it has been in public use in this country for more than two years prior to the date upon which the application for the patent was filed. As prior use has to be proved beyond a reasonable doubt, the utmost care has to be taken to be sure that the witness make no mistake either as to the construction of the device or the date when it was used. It is easy for a man to be honestly mistaken on such a point, but the mistake should be discovered before his testimony is taken, not afterwards. For the purpose of discovering such prior uses it is my custom to send circulars to our members as soon as suit is brought, asking them for any information in their possession. This may sometimes cause considerable work on the part of the members, but is performed cheerfully, it being realized that the benefit of one is the benefit of all. An unfounded claim if improperly defended might, in view of the number of roads interested, result in the loss of a large sum of money. A claim against one road may be small, but when you multiply it by a number of roads it becomes large; hence no question is really so small that I can safely take the chance of overlooking any possible defense, no matter what labor may be required to discover and develop it.

It is a common error to suppose that because a device is patented it cannot infringe any previous patent. Nothing is more erroneous. As an illustration: Thousands of patents have been issued for telephone appliances, but during the existence of the Bell patent none of these could be used, even though patented, without infringing that patent. If one man has a patent on the foundation of a building and a subsequent inventor takes one out on the first story, and one coming still later patents the second story, neither the man who controls the first story, nor he who controls the second, can use his device without using the foundation also, in which case the patent on the foundation would be infringed. In other words, the issuance of a patent by the United States Patent Office is not and does not purport to be a guarantee of any sort that the device covered by such patent does not infringe some other patent granted to an earlier inventor. In this case while the owner of the first patent cannot use the improvement or addition, neither can the later patentee use what is covered by the original patent.

Where I find infringement I am ready at all times to hear the vendor or his attorney in opposition to my opinion. I have frequently voluntarily offered to supply-men an opportunity to present in person or by attorney their views as to their side of the controversy. As a result of such presentation I have sometimes withdrawn opinions already rendered, finding upon the new information given me that my previous opinion was inaccurate. I am more than grateful for any information which any supply-man can furnish me with reference to questions before me. So far as I have any pride of opinion, it consists in getting my opinions right, and as a first step to getting them right, full information is an essential requisite. It often happens that this cannot be furnished by the road, in which case I am not only willing but anxious to receive it from any available source. It may be that after listening to counsel I am unable to recede from my belief that there is infringement; in other words, it is impossible to always waive my judgment in favor of other counsel, however eminent. I can then only regret the necessity of interfering in sales which would otherwise be made, but this is my duty in a proper case.

I frequently hear that my opinions are considered ultra-conservative. Possibly so. It is my rule never to pass a device that is a bald copy of a patent without an absolutely perfect defense, and this rule has repeatedly received the endorsement of our Executive Committee. It is further my rule that whenever I think a device is an infringement, although not a copy, a defense to the patent must come at least as close to such patent as does the infringing device. If this be ultra-conservative, I cannot help it. It is the only safe rule, and I have yet to find any lawyer skilled in the patent law who has been willing to say that occupying the same position he would adopt a different course.

If a supply-man comes to me and says that I am clearly wrong in my opinion that there is infringement, or that the patent I think infringed is bad, but furnishes me nothing but assertions without satisfactory proof, I cannot see that there is ground for criticism if I say, "Very well, if that is your opinion, back it up. Sell the device to the road, but agree to protect it. If you will not do this you cannot be so confident of your position and there is no reason that occurs to me that we should take the risk, which is great enough even with protection."

One word upon this question of what constitutes full protection. Some time ago it was considered sufficient for a vendor to guarantee the cost of litigation, but upon looking into the matter I decided, with the approval of the Committee, that such a guarantee was of little value. We can defend litigation more cheaply than most, and the expense of such litigation amounts to little compared with that incurred by being forced to take off a device because the courts have held it an infringement. It is my view of a guarantee that if it is to be of any value, it should put the road dealing with the guarantor in the same position after an adverse decision that it would have occupied had it not so dealt. Suppose you spent $100,000 under a guarantee to protect you against litigation. Suit is then brought against you under a patent already litigated and held valid and infringed by the court of last resort. You have no defenses other than those decided to be insufficient. What possible satisfaction is it to you to have the vendor pay the expense of litigation when you know that in the end you have got to come to the patentee's terms or abandon the device. It was thought by some of our roads that a guarantee against the expense of litigation included this item of scrapping an appliance, but in taking it up in a noted case the vendor said, "Go ahead with your suit and we will pay the expense." "Yes," we said, "but will you pay us what we are going to lose when we take off the device?" The answer was, "No," and from that answer dated the bond which we require in every instance where a bond is called for, and which protects us not only against the cost of suit, but also against the expense incurred by having to stop using the particular device.

We do not in all cases insist upon protection in the form of a bond. It is sometimes sufficient to merely insert in the contract of purchase a clause guaranteeing the purchaser in the proper manner, in accordance with our rules. I have once or twice even taken a letter from a vendor and in one instance at least have taken a bond to the Association for the benefit of all our members. Which one of these various forms of protection is to be adopted necessarily depends upon the facts in each case. Among such facts which are influential, if not controlling, are the amount involved, the question whether there is actual or merely threatened litigation, and the financial standing of the guarantor. This latter point may be affected by the number of bonds which such guarantor has had to issue. It may readily be that while a manufacturing concern can give two or three bonds, it might not be able to stand behind fifty, so that the conditions might change with time from what they were when the matter first arose. That is, while we might be content with the bond of the vendor in the first instance, it might be necessary to insist upon a surety company's bond later on.

There is one thing the Association does not do, and that is solicit patents, for the reason that a patent obtained for the benefit of one member might well work injury to all the others. Moreover, if I were to attend to taking out a patent for one of our members, it might well be that later on I would be asked to defend suit brought under it against another member. This would put me in a sense upon both sides of the case, which would hardly do.

THE COMMISSION FORM OF CITY GOVERNMENT has recently been adopted by Topeka and Parsons, Kan.—besides Tacoma, Wash., as previously noted. Buffalo and Mt. Vernon, N. Y., have each voted in favor of the commission plan, but must secure state legislation to that end. As we noted editorially on Nov. 11, Boston has voted for charter amendments which substitute a single council of only nine members, elected at large, for the present council of two branches, with large total membership. Taunton, Mass., has voted for a similar change in its council.

The Design of the Broadway or Sparkman St. Bridge, Nashville, Tenn.

By HOWARD M. JONES,* M. Am. Soc. C. E.

Nashville, the capital city of Tennessee, is situated on the Cumberland River. On the west side of the river is the older and larger portion of the city, about 100,000 inhabitants, while on the east side there are about 50,000 people. For a hundred years or more there has existed some sort of a highway bridge at the public square, though the present structure at that point was not built until 1884. Nashville at that time had some 45,000 inhabitants and the population east of the river was very small. Naturally the rapid growth of the city since then has caused the capacity of the bridge to be seriously taxed, and much inconvenience has resulted not only to residents of the east side, but to business generally, by reason of congestion of traffic on the bridge and streets near it. After much agitation of the question of increased bridge facilities the County Court was petitioned to take the matter up. It was soon found that a hopeless division prevailed in the Court as to the proper location for another bridge, and two additional bridges were suggested. This idea met with favor and a special election was ordered by the Court on the question of issuing bonds to pay for them. The project was approved by an overwhelming majority vote.

A Committee of the Court, consisting of Messrs. James K. Rains, Chairman, W. E. Norvell, C. T. Cheek, J. M. Wilson and T. L. Herrin, was appointed and instructed to take all necessary steps to carry out the work. The writer was employed by the Committee as Chief Engineer to design the bridges and look after their construction. The surveys were begun in February, 1907, and pushed as rapidly as possible. Bids on the substructure and approaches were taken in June, 1907, but on account of a delay in disposing of the bonds work was not begun until Sept. 1, 1907. The general contract for the entire work was let to the Foster-Creighton-Gould Co., of Nashville, Tenn.

The bridge on the line of Sparkman St., now known as the "Broadway" bridge, is completed and this paper will be confined to description of it and of methods used in its design.† The west approach begins at Fourth Ave. (see Fig. 1) and rises on a 4.8% grade 388 ft. to Third Ave., this part being made an earth fill retained by a U-shaped reinforced-concrete wall; thence it continues to rise on a 4.1% grade to the west bank pier, crossing three streets and the freight yards of the Tennessee Central Railway. From Sta. 3 + 88 to 9 + 60 the construction is of the reinforced-concrete trestle type with steel plate girders at the street crossings and from 9 + 60 to 11 + 50 it is composed of two spans of concrete bow-string trusses. These spans are on a skew, the longest being 105 ft. c. to c. of end bearings, and the shortest 90 ft. The river proper is crossed by means of three steel truss spans, two 175 ft. c. to c. of end pins and one main channel span 318 ft. c. to c. of end pins. The short spans are on 1.0% grade, and the long span is on 0.5% grade, the high point of the grade being at the east channel pier. From Sta. 18 + 28 to 31 + 50 the east approach descends on a 4% grade ending at the intersection of Shelby Ave. and Second St. This portion is of the reinforced-concrete trestle type except for three deck spans of steel construction, and the end is an earth fill. All steel spans are floored with concrete, and side elevations of all steel spans on approaches made a similar finish to the concrete viaduct. The alinement is straight from Sta. 0 to 11 + 50 where it has an angle 14° to the north; it continues on this latter line to the end, at Sta. 31 + 50.

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†In Engineering News, Feb. 25, 1909, p. 199, there appeared an article on some features of the construction of this bridge. This article, entitled "Concrete Work on Sparkman St. Bridge, Nashville, Tenn., by W. F. Creighton," contains information and illustrations to which the reader is referred.—Ed.

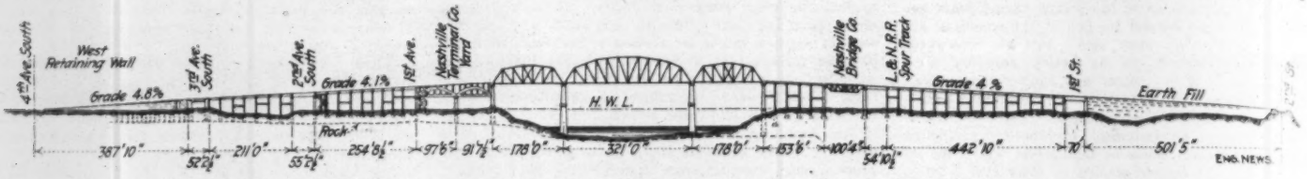


FIG. 1. ELEVATION OF THE BROADWAY OR SPARKMAN ST. BRIDGE, NASHVILLE, TENN.

Fills.

The fill on the west end is entirely contained by reinforced-concrete walls. The east side fill has a wall only on the First St. face, between Second and First Sts., the fill being permitted to take its natural slope of 1 on 1½. The fill on the west end contains 6,309 cu. yds.; the east fill contains 43,114 cu. yds. The west fill was made by hauling in waste excavation by wagon from various points in the city. The east fill was made with a steam shovel placed in a borrow pit near the site and loaded directly into dump wagons of 1½ yds. capacity. The pit was carried to a depth of about 30 ft. The following clause from the specifications shows the method of making fills.

All fills shall be carried up in horizontal layers and not more than 2 ft. thick, and slopes must be kept to proper line as the work progresses. The contractor may dump filling material from cars on any portion of fills, but materials thus unloaded must be placed by scrapers in horizontal layers as above specified across the entire surface of the fill.

Fills 15 ft. high and under shall be carried an average of 9 ins. above subgrade. Fills over 15 ft. in height shall be carried 1½ ft. average height above subgrade, and all fills shall be completed full 60 ft. wide at height above subgrade stated.

These fills were completed in October, 1908, and after the heavy winter and spring rains have settled to about the original subgrade. Bermuda grass seed was planted on the slopes of the east fill in April, 1909, and it has already covered the entire sides. This will no doubt act as an effectual check to further washing. Anticipating, however, further settlement, a temporary surface finish was given the tops of fills. Fig. 2 shows in detail the character of top wearing surface.

The following extract from the specifications helps to explain the construction:

BEDDING.—The bedding stone shall form a layer 8 ins. thick after cracking down to receive the macadam. It shall cover full length of fills and a width of 42 ft. All bedding stone shall be sound, compactly placed, and broken to pass an 8-in. ring. After being placed on the grade it shall be cracked down with hammers so that all exposed stones on the top surface thereof shall pass through a 3-in. ring. The bedding course shall be passed upon and approved by the Engineer or his inspector before the macadam is spread thereon.

MACADAM AND TOP DRESSING.—All macadam and screenings shall be free from dirt, rotten or inferior stone. The macadam shall be from ¾-in. to 2-in. sizes. The top dressing shall be screenings ¾-in. down. The macadam shall be placed in a uniform layer over bedding stone 5 ins. thick after rolling and the top dressing 1 in. thick after rolling on top of the macadam. The finished surface of roadway shall be truly parallel to crown and grade of street. The macadam and top dressing shall be thoroughly wetted and compacted by rolling with a road roller weighing not less than 10 tons.

SIDEWALKS.—The sidewalks shall be made of a layer 4 ins. thick of macadam and a layer 4 ins. thick of screenings; the top layer to be thoroughly wetted and rolled with a hand roller.

It is believed by the time this shall need to be replaced the fill will be solid enough to receive a more permanent treatment.

Retaining Walls

WEST WALL.—The site on which the wall at the west end was built was in years past a hollow with a general level about 22 ft. below street grade. It had been used as a city dump in the recent past until the filling reached street level and was then converted into a public square locally known as the Haymarket. Naturally the character of the filling material was treacherous, and it was deemed unsafe to found any of the high portions of the wall on it. Fortunately rock was only about 2 ft. underneath the old original surface, so it was decided to go to rock for foundation. This was done in a somewhat unusual way. Fig. 3 is a typical plan and section of a part of the wall. The assumptions made in preparing the design were:

(1) The overturning force was assumed equal to the pressure of a liquid weighing 30 lbs. per cu. ft.

(2) The pedestals from rock to bottom of floor, tied together at the top with reinforced concrete and surrounded by earth backfill puddled or tamped, are rigid, and the plane where stability criterion should be applied is at the top of these pedestals.

(3) Loads resisting overturning are the weights of concrete, filling material on horizontal floor and counterfort; resultant of above forces to lie within the middle third.

(4) The horizontal floor was calculated for the vertical load resting on it, assuming it entirely unsupported underneath.

(5) The face walls were calculated to resist the pressure of a liquid weighing 30 lbs. per cu. ft.

(6) Floor was treated as continuous slabs, span length equal distance c. to c. of counterforts ($M = Wl/12$). The face walls were considered only partially continuous ($M = Wl/10$). All overturning moments were concentrated on counterforts and these designed to resist same.

(7) As the forces acting on the retaining walls are from dead loads, it was considered entirely safe and proper to use a lower grade of concrete and somewhat higher unit stresses than on the viaduct where vibratory loads were to be taken care of. The concrete used on the retaining walls is what is classified in the specifications as class "B." It is made of one part Portland cement, three parts sand, six parts broken stone.

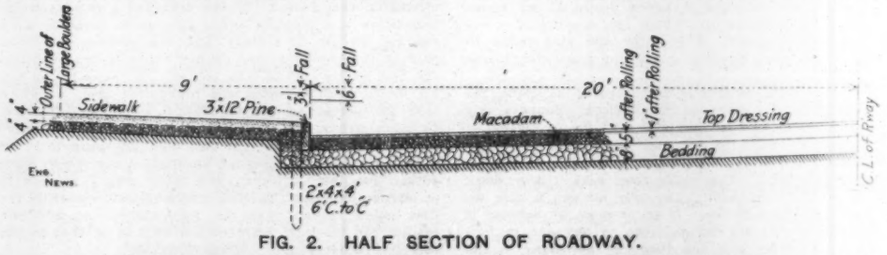


FIG. 2. HALF SECTION OF ROADWAY.

The units used were:

Modulus of elasticity, E_c, 1,500,000 concrete.

Modulus of elasticity, E_s, 29,000,000 steel.

Ultimate stress on steel, f_s, 48,000 lbs. per sq. in.

Ultimate stress on concrete, f_c, 2,000 lbs. per sq. in.

y_1 = dist. from outside compression fiber to neutral axis.

y_2 = dist. neutral axis to center steel.

$$\frac{E_s}{E_c} = R = 19.3.$$

$$\frac{f_c}{f_s} = r = 24.$$

Resisting moment for 1 ft. width, parabolic formula.

$$= 24000\, y_1^2 \left[\frac{5}{12} + \frac{2r}{3R}\right]$$

$$M = 29{,}700\, y_1^2$$

$$y_2 = 1\tfrac{1}{4}\, y_1$$

$$y_2 = \frac{r}{R}\, y_1$$

$$12\left(\frac{2\, y_1}{3\, r}\right) = \frac{y_1}{3} =$$

Area of steel for 12 in. width.

A factor of safety of four was used for all loads.

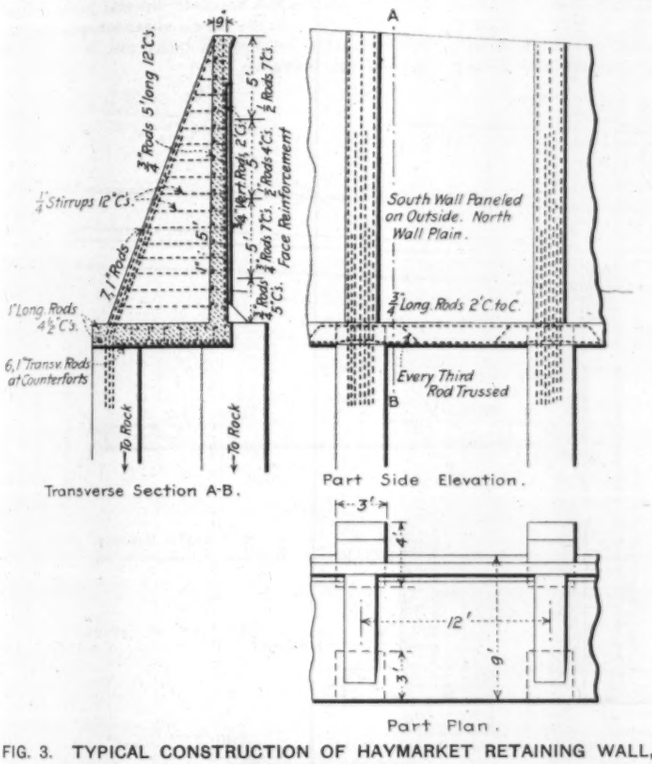


FIG. 3. TYPICAL CONSTRUCTION OF HAYMARKET RETAINING WALL, BROADWAY BRIDGE.

For example: Floor where earth fill is 24 ft. above top of concrete.

$$M = \text{earth}\ \frac{24\times100\times10\times12^2}{12} = 288000 \text{ in lbs.}$$

$$\text{concrete}\ \frac{1.5\times140\times10\times12^2}{12} = \frac{25200}{313200}\ \begin{matrix}\text{“ “}\\ \text{4 fact. of safety}\end{matrix}$$

Total M 1,252,800

Reinforcement

$6.5 \times .33 = 2.14$ sq. in steel for each 12 inch width of slab

$29700\, y_1^2 = 1{,}252{,}800$ inch lbs.

$y_1 = 6.5$ in.

$y_2 = 8.1$

Allow from c. of st. to bot. of beam 2.0

16.6 in. total thickness of slab.

Plain round rods were used in all retaining walls. It was thought, with a maximum stress of 12,000 lbs. per sq. in. figured on the steel it would be a useless expense to specify deformed bars. In the floors, part of the rods were trussed to take care of the shear stresses and reverse moment stresses at supports. On the face wall, where only partial continuity was counted on, all main reinforcing rods were straight, but to care for change at counterfort, ¾-in. rods 5 ft. long were placed every 12 ins. near the back face. As no signs of any cracking appeared at the junction of face wall and counterforts when filling was done the provision for the reverse bending was no doubt ample.

On account of the necessity of anchoring the counterfort reinforcement in the rear pedestals, and of facilitating construction also, the counterforts were made of greater depths than the formulas required, so this excess depth was taken advantage of to reduce the amount of reinforcement. The method used was as follows: At a height of 26 ft. the actual figured depth required from face to center of steel was 63 ins., but as built it was 102 ins. The lever arm of the tension force was assumed as 8/10 of 102, or 81.6 ins. The total overturning moment being 11,500,000 in.-lbs. the tensile stress equals this divided by 81.6, or 140,931 lbs. stress in the steel, which divided by 10,000 (unit used under these conditions for the counterfort reinforcement) gives 14.1 sq. ins. as the steel required.

The counterfort reinforcing was ordered in three lengths, one third extending to top of wall; one-third for two-thirds the height of wall; and one-third for one-third the height of the wall. All counterfort reinforcing was properly tied by stirrups to the face wall steel. The low portions of this wall were founded direct on the made ground, involving a change in the style of floor. A wide cantilever toe was extended in front of the face. On the north side a part of the wall rested on water saturated ground which was very soft. This was compacted by excavating below the foundation for several feet the trench filled with macadam which was rammed and grouted. The wall was then founded on this. No settlement has yet occurred at this point.

EAST WALL.—This wall retains the fill at First St. and carries one end of a 72-ft. deck girder span. It is 36 ft. high from bottom of footing to top of parapet. It rests directly on the clay. It is in a bottom which is at all times practically saturated with water, and in which large crawfish holes appear at all too frequent intervals. At first glance it looked as though a foundation was going to be difficult to secure. However, after a closer study of the material, the conclusion was formed that it was all right. The material was a stiff brick clay for a depth of from 10 to 14 ft. underlaid with a mixture of clay and sand, sand predominating, about 30 ft. thick and then a layer of gravel about 6 ft. thick down to rock. The footing was placed about 5 ft. below the surface and the precaution was taken to place drain tile around the footing, this drain being connected up to a sewer, in order to keep the bottom as dry as possible. Some fears were expressed by foremen and workmen that a united effort on the part of the large crawfish might overturn our wall, but we did not take much stock in the wonderful strength of these animals, and proceeded to build the wall. The average calculated pressure on the footing is 3,360 lbs. per sq. ft., and the maximum pressure at the toe might reach as high as 6,700 lbs. per sq. ft. if the horizontal overturning force is ever as great as assumed, which we very much doubt. Fig. 4 shows a typical section of this wall. The toe was calculated as a cantilever beam supported on the face wall. The reinforcement and forces acting on the floor varies. Near the inside of the face wall the upward thrust of the reactions being greater than the vertical load the part of floor adjacent to face wall was reinforced on the top side. On the rear third the vertical force exceeded the reaction, and this part of the floor was reinforced for the full vertical load. The wall has already no doubt undergone the greatest strain which will ever come upon it, for the fresh fill has settled. It shows no signs of settling out of plumb or cracking. It no doubt would have been possible to have built a wall with less steel used in the floor, but it was thought best to reinforce for all possible conditions of loads.

Reinforced-Concrete Trestle.

In the approaches 1,060 lin. ft. is of the reinforced-concrete trestle type structure. The height ranges from 18 to 50 ft. above the surface. The columns supporting the bent next to the river on the east side are 69 ft. from the bottom of footing to bottom of floor beam. This is thought to be the longest highway concrete trestle bridge of its character in the United States, and being designed for heavy city traffic, which included a double-track steel railway, it necessarily presented many new points for study and determination. It is built mainly in 30-ft. bays, every other bay being braced by horizontal struts both longitudinally and transversely with the axis of the bridge, at points approximately half height of columns above the surface. Fig. 5 shows the

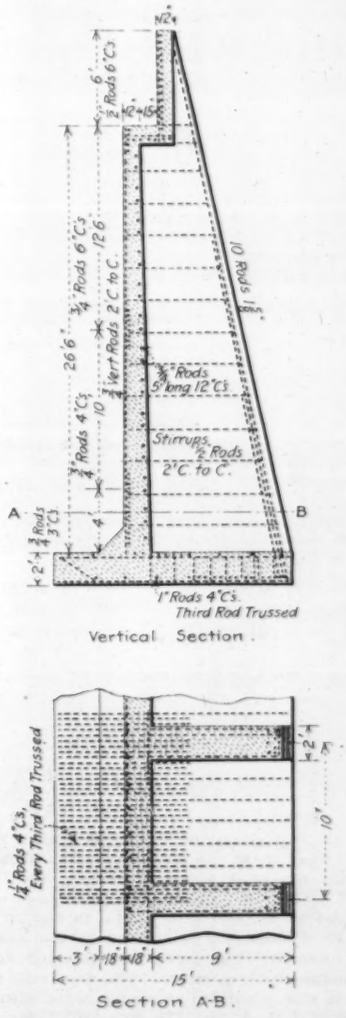


Fig. 4. Typical Construction of Retaining Wall at East Approach of the Broadway Bridge.

details of the design of typical 30-ft. section. It was determined in the outset to use very conservative unit stresses both on steel and concrete, and loads for figuring the stresses which would not likely be exceeded. It was decided that the reinforcing of all stringers and floor beams should be bars with a mechanical bond to provide ad-

ditional security against the slipping of bars or loss of adhesion by reason of being called upon to resist vibratory loads. The columns and floor slabs were to be reinforced with plain round steel bars. This difference in reinforcing for the floors was because of the fact the rods were ordered in long lengths extending over several spans of the floor slab, and as it was extremely unlikely that all spans of the slab would ever be loaded at the same time, the adhesion of the concrete to plain steel was considered amply sufficient. Round rods were also used in the footing reinforcement, the reason for this being that the effect of impact was practically nothing on the footing, and therefore there could be no danger of adhesion being disturbed.

The grade of the concrete used in the reinforced trestle was richer than in the retaining walls, being composed of one part cement, two parts sand and four parts stone. The steel used

Dead load

5 in. slab	-	60 lbs. per ft.
Sand -	-	10 " " "
Paving	-	40 " " "
Total	-	100 lbs. per sq. ft.

multiplied by factor of safety, 4, gives 96,484 in.-lbs. as the moment to be resisted. Apply formulas

$$35100\ y_1^2 = 96500$$
$$y_1 = 1.65 \text{ inches}$$
$$y_2 = 2.27 \text{ "}$$

c. of steel to bot. slab = 1.08

5 in. thickness.

Area of steel for 12 in. width = $1.65 \times 0.4 = 66$ sq. in. Use ½ rounds spaced 3½ c. to c.

The stringers "A" (see Fig. 5) were designed to carry street railway tracks on which would run trains made up of 40-ton motors and 30-ton trailers. The span of stringers is 30 ft. c. to c. of floor beams. The maximum combined moment is at the center of stringer and occurs when the rear axle of motor is on the center and the trailer following (Fig. 6). The live load moment for this position is 143,740 ft.-lbs. As the stringers are made continuous by trussing bars and lapping over floor beams this fact is taken advantage of

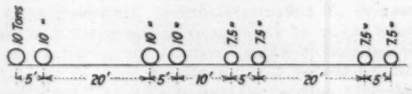


Fig. 6.

to reduce the moment stresses. However, perfect continuity is not counted on, but it was considered perfectly proper to assume the moment at 8/10 that of a simple beam under same conditions.

Diagonal shear at approximate section of reversal of moment stresses is amply provided for by trussing reinforcing as shown on the typical section. Direct shear at floor beams is also amply provided for. Similar methods were used in the design of all other stringers, though, of course, different loads were used, as follows:

Live load on stringers B. 150 lbs. per sq. ft.
Live load on stringers C. 150 lbs. per ft on the roadway side and 100 lbs. per ft. on the sidewalk side.
Live load on stringers D & E. 100 lbs. per sq. ft.

The floor beams are supported by three columns 20 ft. c. to c. and cantilever beyond the outside posts 9 ft. The maximum direct moment on floor beam occurs when the full live load is on half roadway and off the other half and sidewalks. Under this condition the point of maximum moment was found to be under the outside "A" stringer. The maximum combined moment at this point was 7,578,000 in.-lbs., which multiplied by the factor of safety, 4, made a total of 30,312,000 in.-lbs. to be resisted. In obtaining the dead moment it should be borne in mind that the floor beam is continuous over three supports. The maximum negative moment at the middle post occurs when all of the roadway is loaded and the sidewalk unloaded. The section adopted fulfilled the conditions for negative moment. The stresses for the bracket end of floor beam were determined in the usual manner for a beam fixed at one end. The depth of main floor beam was found ample for the bracket. Special precautions were taken to provide for all shear stresses in the bracket, extra reinforcing being put in near the ends of the brackets.

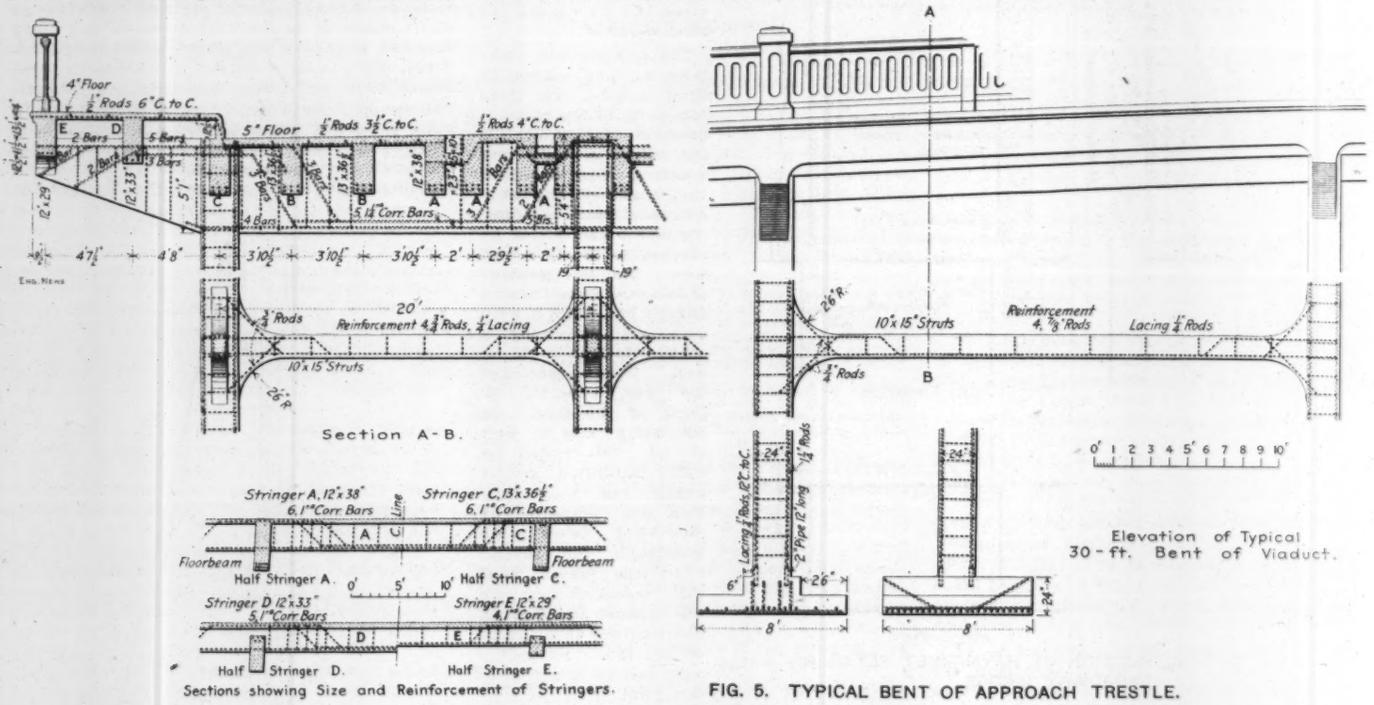


FIG. 5. TYPICAL BENT OF APPROACH TRESTLE.

was medium open hearth, elastic limit not to exceed 45,000 lbs. per sq. in. Units and formulas used in design follow:

$Es = 29{,}000{,}000$	$fc = 2{,}200$
$Ec = 1{,}500{,}000$	$R = 14.5$
$fs = 44{,}000$	$r = 20$

Area of Steel for 12 in. width $= 12 \times \frac{2}{3} \frac{y_1}{r}$

$$\frac{r_1}{R} y_1 = y_2 = 1.38\ y_1$$

$$M \text{ for 12 in. width} = 12 \times 2200 \left(\frac{5}{12} + \frac{2}{3} \frac{r}{R} \right) y_1^2$$

On all floor slabs and beams an impact allowance was made in accord with Waddell's formula for steel highway bridges, viz.: $P = 10{,}000 \div L + 150$, where P = percentage of the live load stress, and L = length, in feet, of span or part of span that is covered by the live load when member considered is subjected to the maximum live load stress. The floor slab of the viaduct was calculated as simple beam with span length of 3 ft. 6 ins. The live load assumed on the slab was a wheel load of 5 tons distributed over a space 4 ft. long by 3 ft. 6 ins., or 710 lbs. per sq. ft.

Below is the computation for a slab.

Live load moment	= 13000 in. lbs.
Impact, 70%	= 9100 " "
Dead load moment	= 2021 " "
Total moment	= 24121 " "

No allowance for impact was made in determining the section for the columns. Columns were proportioned so that the unit stress in direct compression should not exceed 500 lbs. per sq. in. on the total section. The section of concrete was made large enough to resist the stresses without counting on the steel at all. After the proper allowances were made for the increased load at middle posts on account of continuity over three supports and decrease because of the cantilever brackets, it was found that the load on the middle column might reach a total of 282,800 lbs. at foot of column with two panels fully loaded, and therefore a column 24 x 24 ins. was required. To make the columns additionally secure, to provide also against any possible flexure, and to tie the structure effectually together, each column was reinforced with four longitudinal rods 1¼-in. diameter laced every 12 ins. with 5/16-in. round lacings. The loads on the outside columns were considerably less than on the center ones, but for the greater portion of the viaduct were made same section as the center. On the low portions they were reduced to 20 x 24 ins. The struts between columns reduced the unsupported column length and helped to resist wind stresses. The unsupported length of column varies from 10 to 16 times the least dimension.

Some of the pedestals of 1:3:6 concrete were built from rock up to within 1 ft. of the surface as footings for the reinforced work, and all the remainder of the viaduct trestle columns rested on reinforced footings shown on typical section and plan, these footings being built on good clay. As will be seen, the type of footing is, first, a

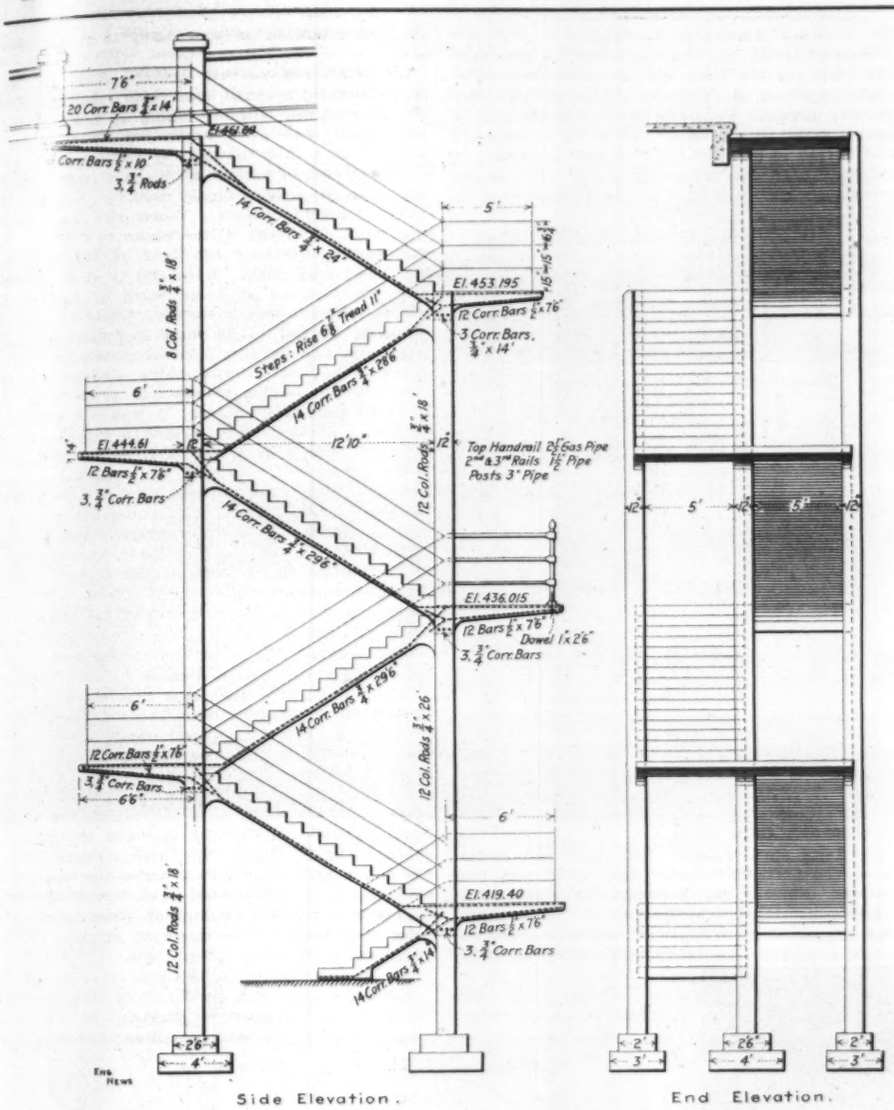


FIG. 7. REINFORCED-CONCRETE STAIRCASE, BROADWAY BRIDGE.

beam supported at the middle by column and this beam in turn supporting a reinforced slab. The maximum pressure on the footings is about two tons per sq. ft. On the east side rock is fully 50 ft. below the surface, overlying the rock is first a layer of gravel, then sand, and on top a good clay. The clay in some places is at all times practically saturated, but that the foundations are ample seems to be proved by the fact that not the slightest sign of settlement has yet occurred at any of the footings.

The brackets supporting the sidewalk stringers are carried out level with the top of floor beam at its junction with the outside post, and the sidewalk stringers are raised on this bracket so as to provide an open space between the bracket and bottom of sidewalk slab. This was done in order to accomplish several useful purposes: first, it gives an excellent depth of curb without a waste of material in the bracket; and, second, it provides an open protected space for carrying wires, pipes, conduits, etc., across the bridge. A portion of this space was utilized for carrying the electric feed wires for lighting the bridge.

The roadway is crowned 3 ins. in its width and this was secured by making the floor beam deeper at the middle post than at the side columns. The sidewalks are given a fall of 1 in. in their width of 10 ft.

The street railway tracks, which were provided for, will not at present be laid, and it was not known just when the street railways would secure rights on the bridge, but knowing it to be only a matter of time until they would want to go across, provision was made for a double-track line. The stringers to carry the tracks were arranged in pairs with a shelf between them, thus forming a groove in which it is the purpose to place a creosoted timber plate to which may be attached the rail. This arrangement does away with any necessity of cross-ties; offers an unyielding, continuous support to rail, thus producing the minimum amount of shock on the structure, and repairs and renewals can be made without injury to the concrete. At all street crossings, reinforced stairways were built. The general type of the stairs is shown by Fig. 7. The platforms are cantilever slabs, while the steps are calculated as beams supported at the ends. Gas pipe railing was used on all stairs, except those at the west retaining wall, and there a hand rail similar to that on the main approach was used.

EXPANSION JOINTS.—The writer in studying the subject of expansion found the information he could gather very unreliable, and opinions of engineers widely varying. The viaduct, as has been stated, has steel girders at all street crossings, and these girders rest on piers composed of three columns joined together at the tops with reinforced-concrete arches. Thus at these points was afforded an opportunity for making expansion joints. One end of all steel girders was fixed and the other free. All ends of the concrete viaduct resting on these piers were finished on sliding shoes so that if expansion took place in the concrete structure movement could take place on these piers. The distance between such expansion joints varied from 150 to 400 ft. The structure has now been through a winter and summer, and the writer has had these free ends examined carefully and there is no evidence of any movement of the concrete structure. It should be stated, however, on the other bridge, which is not yet finished at one of the fixed ends of the concrete viaduct over the bank pier, expansion sufficient to crack the front end of stringers has occurred.

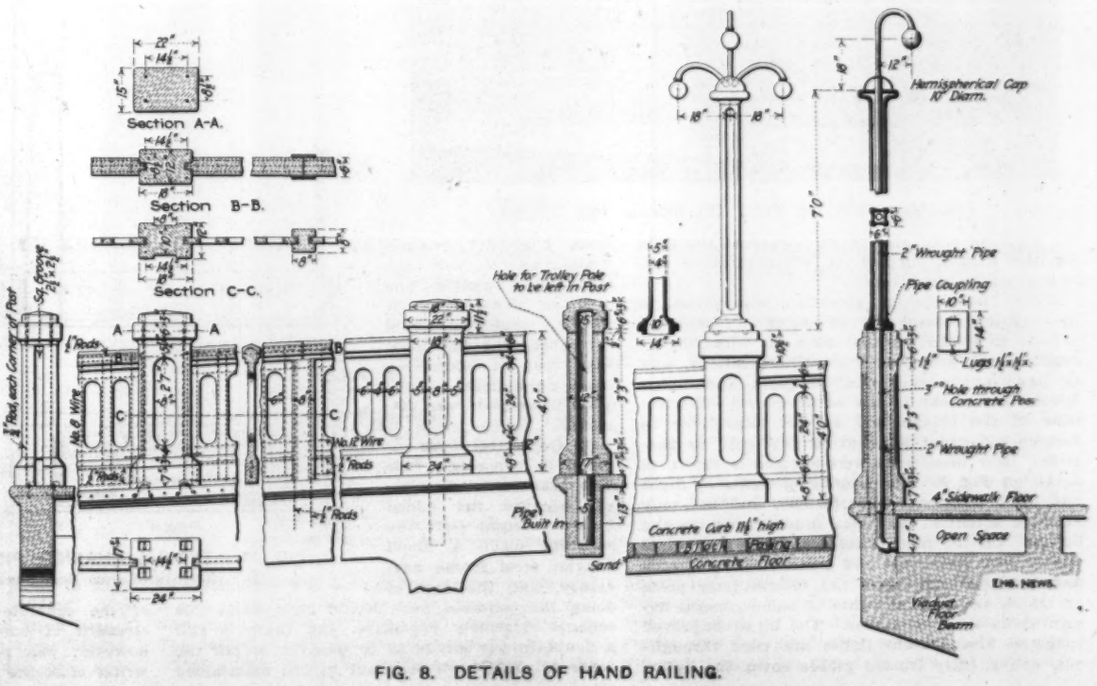


FIG. 8. DETAILS OF HAND RAILING.

HAND RAILING.—It was the purpose of the writer to make the general lines of the bridge as pleasing as conditions permitted, and to depend more on its appearance as a whole than on a multiplicity of ornamental details. It is no easy task to make the trestle type of bridge architecturally attractive, and it is thought the problem was met in this structure with at least a degree of success. On the approach the hand rail is the main feature of the ornamental scheme. Fig. 8 shows in detail its construction. It was comparatively easy to construct and, while light, is very rigid. The open panel work gives it the appearance of lightness, a very desirable end to attain on a structure where the deck looks heavy in comparison with the column supports, in spite of all that can be done. A simple cornice was made on the outside stringers, and where these stringers joined the brackets, curve fillets were molded, thus very materially relieving the straight lines. All struts between the columns were also curve filleted at the ends for the double purpose of ornamentation and strengthening the struts.

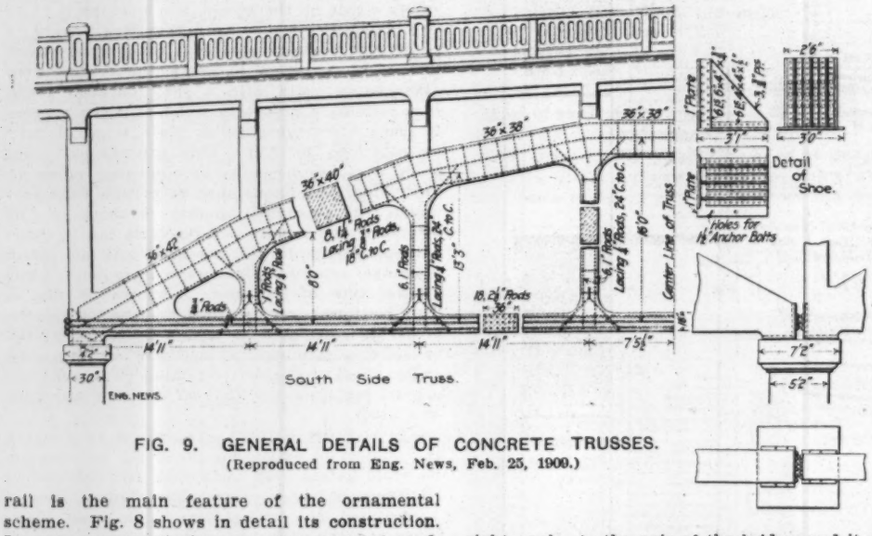


FIG. 9. GENERAL DETAILS OF CONCRETE TRUSSES.
(Reproduced from Eng. News, Feb. 25, 1909.)

LIGHTING.—Special attention was given to the lighting scheme for the bridge. The main objects to attain were to have all wires in accessible, yet protected, concealed positions, and to have an arrangement of posts and lights which would add to the architectural effectiveness of the bridge and at the same time to furnish plenty of light at as low cost as possible. How these ends were secured is shown in detail on Fig. 8. The display of lights at night has more than met expectations, and not only attracts attention but also much travel to the bridge. On the main steel spans the feed wires are carried inside the end posts and top chords and branches run down the intermediate posts on which are bracket lights of same general design as on the approaches. The latest improved tungsten incandescent lights are used throughout, and slightly frosted globes cover the lights.

Concrete Trusses.

Between First St. and the river on the west approach are the team freight yards and passenger depot of the Tennessee Central Ry. The railway company naturally objected to the trestle approach being continued across their property, and agreed to give the right-of-way necessary, if only one pier was put in the yards. To further complicate the crossing, the tracks were not at right angles to the axis of the bridge, and it was necessary to place the pier on a skew with the bridge, it being askew 15 ft. in 40 ft. width. Consideration was given to several plans for crossing over these yards.

(1) Deck steel trusses. This plan had in its favor cheapest first cost. Against it was the extreme difficulty of keeping the steel work properly protected against rust, for its position over the constant exhaust of sulphurous smoke from switch engines would have been the most severe possible. The cost of keeping it properly protected would far exceed the additional first cost of something more permanent, so the steel truss plan was dismissed.

(2) Deck steel truss encased in concrete. This was also finally dismissed, because the added dead weight of the concrete made a much heavier steel frame necessary, and the cost of doing the concrete work would have made this scheme extremely expensive, and there is still a doubt in our minds as to whether or not the concrete could have been put in and maintained in such condition as thoroughly to protect the steel.

(3) Reinforced-concrete arches. This scheme was dismissed because head room required could not be obtained without taking up more of the yard room with piers, abutments and low portions of arch than the railway would consent to. The first cost of arches would have been higher also than the scheme finally used.

(4) Concrete trusses. When this idea first suggested itself, the writer began to investigate engineering literature for light on the subject. He found very little. Here and there he found brief descriptions of some work of this kind which had been done in Europe. These examples, however, seemed to be more complicated than necessary, and usually followed closely the construction of steel trusses, using diagonal members, without having satisfactory connections of these diagonals to chords. It was not possible to locate a satisfactory American precedent, so it was decided to design a truss of the bow string type, but omitting all diagonal members. It is not our purpose here to weary the reader with the various calculations made to determine the safety of these trusses. Briefly the sections of the top chord and the area of steel in the bottom chord were arrived at by assuming the trusses fully loaded with dead, live and impact allowance, all being applied at the panel points as shown.

The heights c. to c. of chords were made so as to keep a constant tension in the bottom chords. It is, of course, true that the live load applied on one-half of truss produces shear and unbalanced moment stresses which cannot be taken care of in the same way as is done in a steel truss with diagonals, but it was believed that by properly reinforcing and filleting the posts at intersections with the chords the truss could be made so rigid as to make the bottom chord assist in caring for these stresses. The top chord was also figured under the eccentric loading as an equilibrated arch rib, hinged at ends and under this assumption (because of the large dead load), the stresses on extreme fibers of the concrete are well within the crushing strength of concrete. This latter assumption, however, has no foundation on fact, for the writer is of the opinion that so long as the ver-

FIG. 10. VIEW OF TEST ON SMALL SIZE TRUSS.

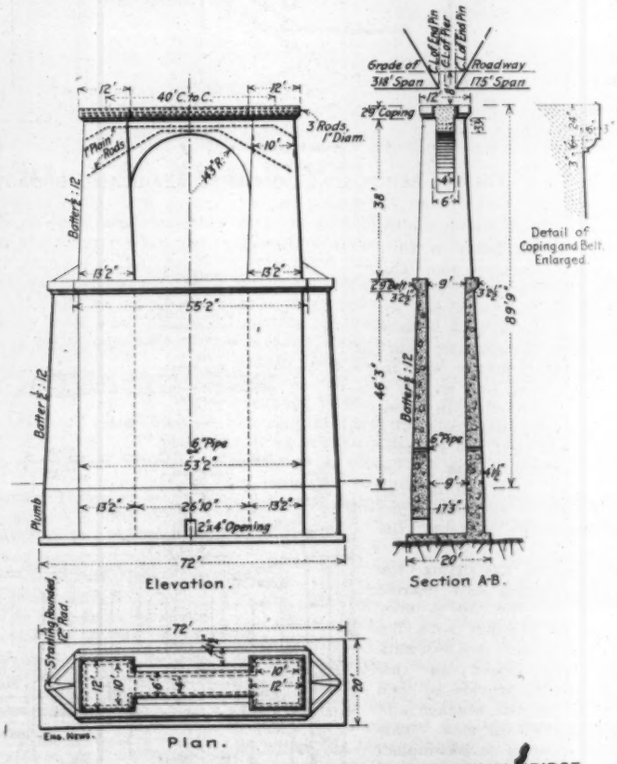


FIG. 11. TYPICAL CHANNEL PIER, BROADWAY BRIDGE.
(Reproduced from Eng. News, Feb. 25, 1909).

tical posts and fillets are intact it acts purely as a truss or trussed beam.

Not being satisfied with any theoretical solution it was determined to make a reduced model of the longest truss and test it to destruction. A model was made of the 105-ft. span reduced to

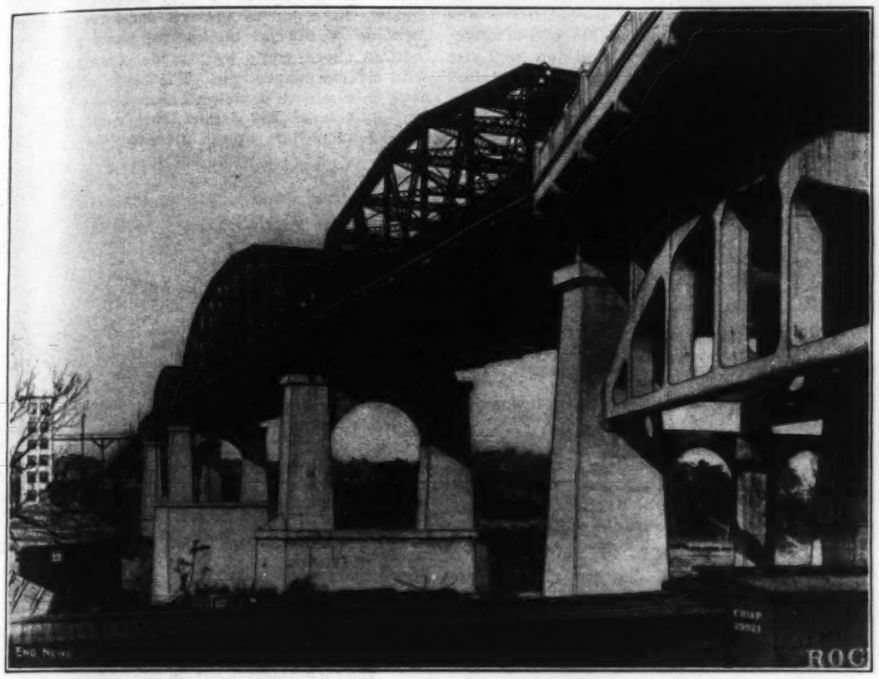


FIG. 12. GENERAL VIEW OF PART OF BROADWAY BRIDGE.

1/100 of the sectional area of the truss to be used. It was made of the same kind of concrete to be used in the large truss and allowed to set 14 days before forms were removed. On removing forms, the lumber between posts had swelled and it was necessary to crack all the posts in order to get forms out. The posts were then chiseled out flush with the chords and new posts cast against the set concrete in bottom and top chords. Thus there were two joints in each post where a very imperfect bond existed. The model was then allowed to set 16 days longer and post forms taken off and the truss loaded. The method of loading was as follows: iron saddles were placed over each of the posts at panel points and heavy timbers laid on the irons; this made a platform on which was piled up heavy iron castings. Fig. 10 shows a photograph of the model under the final load of the test. There was on the model 17,000 lbs., about three times the total of the dead, live and impact loads, and equivalent on the large truss to 1,700,000 lbs. It was expected on account of the defective manner in which the posts were made the model would show signs of failure under eccentric load, but to our surprise no such failure took place under an eccentric load six times as great as it was figured it would ever be called upon to sustain. The reason the model was not tested to destruction was that it became top heavy and it was feared the castings might topple over and hurt some of the workmen who were loading it. The deflection of the model was about 1/16-in.

Under full load the maximum stress on the concrete in the full size truss will be 600 lbs. per sq. in. The bottom chord was reinforced so that steel would take all of the tension and the maximum stress on the steel will be 13,000 lbs. per sq. in. under full load. Fig. 9 shows general details of trusses. The bars in the bottom chord were made in three pieces, these being upset on each end, threaded and connected together by turnbuckles. The trusses terminated at the ends in heavy built steel shoes, shown in detail in the figure. The bars went through the shoes and ends were held by nuts. As the concrete was placed the nuts were kept tightened, and after concrete had set 30 days the nuts were again tightened and centering was struck. The end shoes rest on sliding plates, but up to the present time no expansion has taken place. The trusses are braced together transversely by horizontal struts at bottom chord, half way points and by the deck at top. Before the centering was taken out levels were taken on the top chords of all trusses and again taken after they swung free, and there was absolutely no deflection apparent.

The writer is well aware that the use of concrete in truss construction has been criticised by prominent engineers, and the lack of accurate knowledge of the distribution of stresses under eccentric loading seems to be the chief point of attack. It is also true there was much criticism of reinforced-concrete arches when they were first introduced, yet such construction has continued to grow in favor, and so it is believed by the writer the concrete truss will be found to be an economical solution of many problems of the future, and it will soon cease to be experimental and will graduate with honors from the "freak" list. Another decided point in favor of the truss is that it lends itself to improving the beauty of a bridge. For instance, on this bridge the location of these trusses is such that they are in plain view up and down the river for a long distance, and they add very materially to the architectural effectiveness of the structure.

It may be stated as a general truth the designing engineer needs to be conservative and be sure of his ground before attempting the untried, but it is equally true that progress can only come through courage to do the unusual. He also builds with the knowledge that his work must stand the test not only of known laws of Nature,

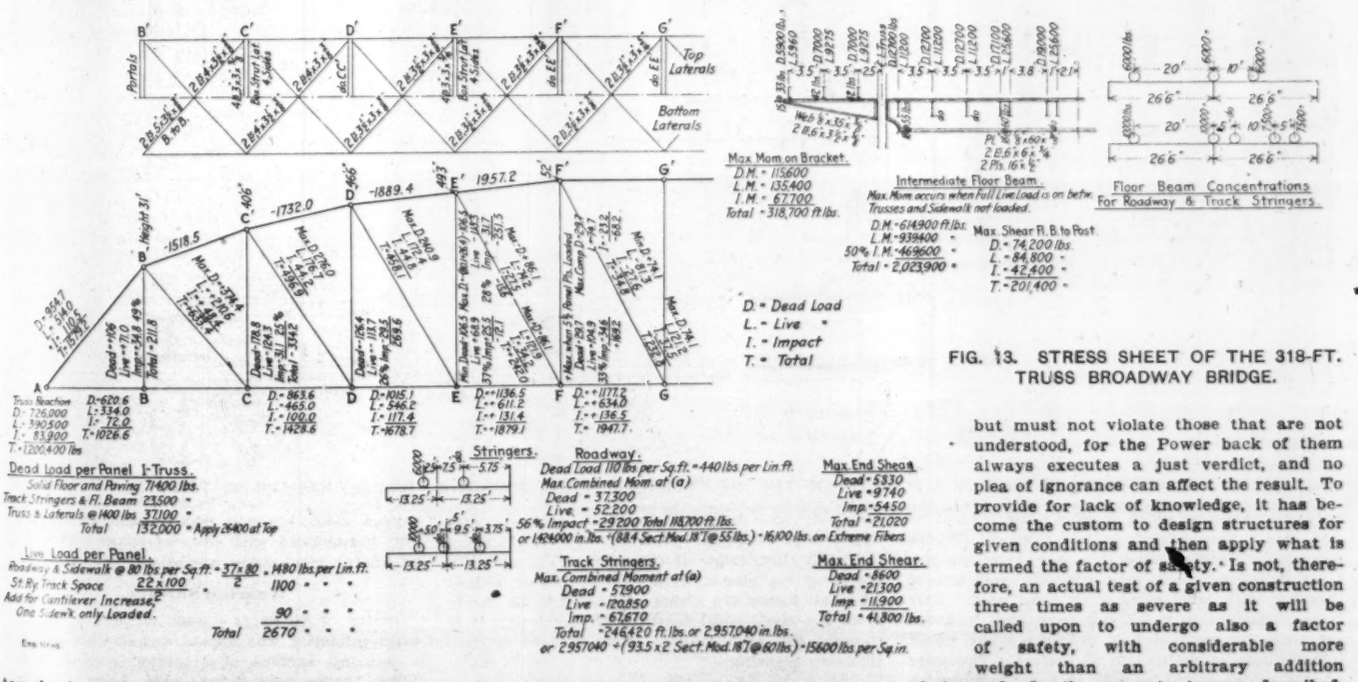


FIG. 13. STRESS SHEET OF THE 318-FT. TRUSS BROADWAY BRIDGE.

but must not violate those that are not understood, for the Power back of them always executes a just verdict, and no plea of ignorance can affect the result. To provide for lack of knowledge, it has become the custom to design structures for given conditions and then apply what is termed the factor of safety. Is not, therefore, an actual test of a given construction three times as severe as it will be called upon to undergo also a factor of safety, with considerable more weight than an arbitrary addition of figures? In the concrete trusses described, conservative unit stresses were used; a thorough test was made of a reduced model; and the designer was convinced they were as safe as any other portion of the structure, although he freely

admits no theoretical solution of the stresses under eccentric loads exactly satisfies.

River Piers.

There are two bank piers and two main channel piers. All are founded on solid rock. When the design of the piers was taken up the points first considered were to take full advantage of the use of concrete by placing the material where it was absolutely essential and omitting it where it was of no special service. It has been the practice in masonry construction to make solid piers. When a wide bridge is to be built this means a large quantity of masonry intermediate course at the top, and by reinforced side curtain walls from the footing course up to the high water line. The curtain walls are 2 ft. thick at the top carried down plumb on the inside, and battering with the towers on the outside. The walls are reinforced with a heavy meshed fabric placed near both inside and outside faces, this fabric extending also entirely around the towers up to top of the curtain walls. By this arrangement about 800 cu. yds. of concrete on each pier were saved over what would have been required by a solid pier.

On the bank piers the curtain walls were carried only a few feet below the surface of ground points. Fig. 13 is a stress sheet a... Fig. 14 shows the general details of the s... n. The weight of the structural steel only in ...s span exceeded 800 tons. The exceptional h... y dead loads keep the counter stresses very ... and it was decided to omit all tension count... and to take care of such stresses by making ... f diagonals. In order to prevent excessive ...ze and bending on pins at the central panel ...nts the bottom chord joints were made combi...n pin and riveted connections. The depth of ... truss was chosen with a view to economy an... ppearance. A somewhat deeper truss would ...ve required some less steel, but after sev... trial

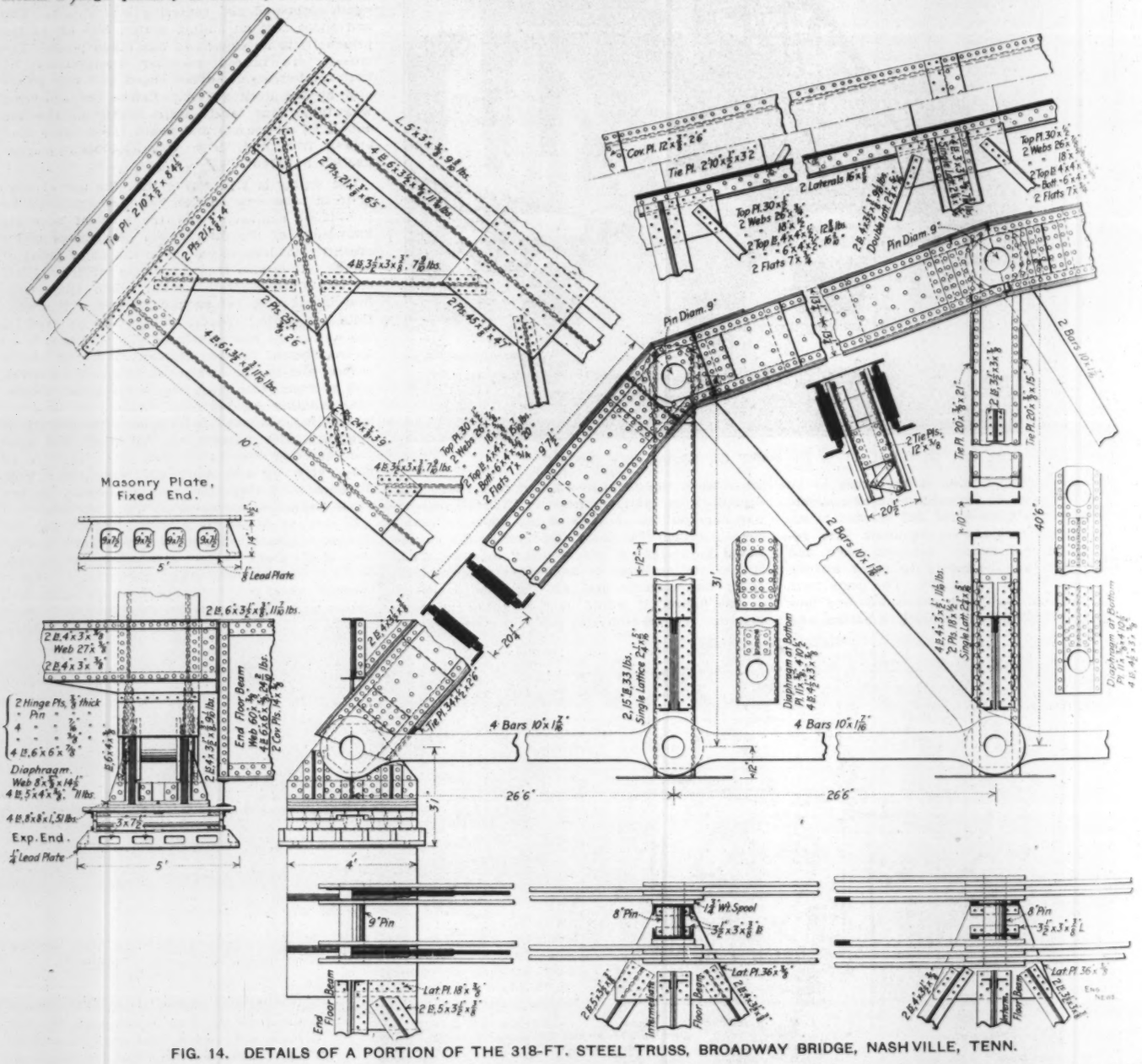


FIG. 14. DETAILS OF A PORTION OF THE 318-FT. STEEL TRUSS, BROADWAY BRIDGE, NASHVILLE, TENN.

between bearings which is of no use, except to add stability where it is not needed. Where economical pier construction has been sought, steel cylinders filled with concrete and braced together with steel have often been used. This latter construction would not have been in keeping with the remainder of the bridge nor would it have been as permanent as desired. The piers of this bridge might be said to be a compromise between the two types mentioned. Briefly they consist of two concrete towers extending from bridge seat to footing course, and battered on all sides ½-in. to 1 ft., being braced together by a reinforced-concrete arch and corbeled coping and only to a height that would give a proper appearance to the pier as a whole. Fig. 11 gives in detail the design of the piers. The stability factor of the pier against overturning or sliding when all forces are acting against it is 22. Aside from the economical features of the design it is thought the architectural effect secured is particularly pleasing.

Steel Trusses.

The steel trusses spanning the river follow in general design present day practice. The main river span, 318 ft. c. to c. of end pins, is, however, unusual enough to call attention to a few depths were viewed it was thought those chosen best harmonized with the end spans. The floors on all the steel spans are of reinforced concrete.

Wearing Surface.

On top of all floors a sand cushion 1 in. minimum thickness was spread and on this was laid a wearing surface of creosoted paving blocks. These blocks were 3 ins. wide, 4 ins. deep and 8 ins. long, all heart-wood long leaf yellow pine and treated with 18 lbs. of oil per cu. ft. An inspector was placed at the creosoting plant and was present during the treatment. The oil was also tested from time to time. The interstices

betwe[en] blocks were filled by flushing with a mixtur[e] of pitch and coal tar, and dry hot sand sprea[d] on top. Expansion joints ¾-in. wide were made [a]long each curb line and at intervals of 50 ft. [t]ransversely across roadway. These joints were [f]illed with a bitumen concrete. As yet no buckl[i]ng of blocks has occurred. Catch basins conne[c]ted to 6-in. cast-iron down pipes were placed on each curb line at intervals of about 150 ft. to care for storm water drainage.

FIG. 1. STEEL CONE AND THROATPIECE OF 120-IN. VENTURI TUBE IN PLACE.

FIG. 2. BUILDING THE DOWNSTREAM CONE OF REINFORCED CONCRETE.

FIGS. 1 AND 2. CONSTRUCTING A HUGE VENTURI TUBE AT THE DIVI ISLAND PUMPING PLANT, MADRAS, INDIA.

Conclusion.

In the early beginnings of bridge construction the architect was the designer. Stresses received scant consideration and symmetry of line was the uppermost consideration. Time of construction was of minor importance, for the conditions of civilization demanded not the haste which to-day is urged. We read of a well known instance in the bygone days when an army had to be passed quickly over a river, and then and there a true engineer sprang into being and built a pile trestle structure for immediate service and all thought of beauty was relegated to the rear. Too often since that day engineers have been forced by public needs to build structures temporary in nature, and devoid of anything that appeals to the aesthetic in man. Particularly is this true in this great country whose rapid development has been beyond compare. However, the signs of the times point to a changing attitude on the part of the people. Not only do they demand of the engineer structures which must be economical, built rapidly, and of permanent materials, but also must they satisfy ideas of symmetry and beauty. No innovation of recent times has so aided the engineer to measure up to the demands, as reinforced-concrete construction. And yet, it is but a babe in its development, and when it shall become grown the civilized world will be full of structures so useful, permanent and beautiful, and that it may now be said the half has not yet been dreamed.

Huge Venturi Meters Registering 625 Cu. Ft. Per Second, Divi Island Pumping Plant, Madras, India.

In the extensive irrigation works of India, with a single exception, it is reported, water has been obtained at a height above the land to be irrigated sufficient to permit of distribution by gravity. The notable exception to this practice is found in the development at Divi Island in the delta of the Kistna River, Madras Presidency. Here the river was the only source of water supply and pumping became necessary in the intervals between the seasonal floods.

The pumping plant comprises eight 160-HP. Diesel engines, direct-connected to low-lift centrifugal pumps with all usual auxiliaries. These main units run at 180 r. p. m., each delivering 73 cu. ft. per sec. against a head of 12 ft. As the lift depends on the seasonal height of the river, the head pumped against varies from nothing to 16 ft. The river is high enough during seven months so that water is admitted directly to the irrigation canals. It was held to be of primary importance to maintain the pumping machinery at its highest possible efficiency in handling this large quantity of water and the only way of accurately determining the daily performance under prevailing conditions was found to be by measuring the quantity pumped, from which the apparent "slip" could be determined. As this measurement had to be made with a minimum loss of head, the designer decided to use two large Venturi meters with flow recorders. The recorders were planned to be merely diagram-drawing and mechanical integrating apparatuses actuated by a clock mechanism and by the pressures corresponding to the velocities through the full and constricted parts of the Venturi tubes. A record is thus furnished of the flow at any moment and of the total quantity passed.

The Venturi tubes installed at the Divi Works

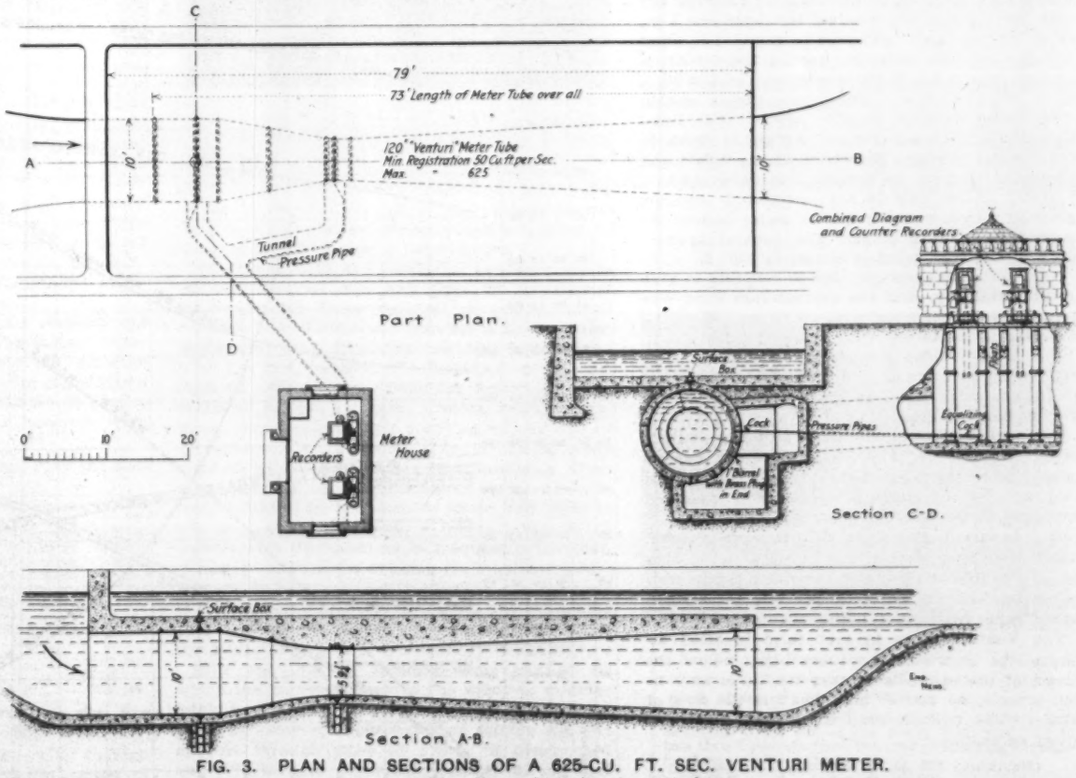


FIG. 3. PLAN AND SECTIONS OF A 625-CU. FT. SEC. VENTURI METER.
(Geo. Kent Ltd., London, W. C.)

are claimed to be the largest in the world and differ somewhat in construction from the type of ordinary water-works. The large diameter of each tube is 120 ins., with a throat ratio of 1 to 3. The

we are indebted for the data, drawings and photographs reproduced here. The original scheme was prepared by R. N. H. Reid, M. Inst. C. E., now of Bezwada, Madras.

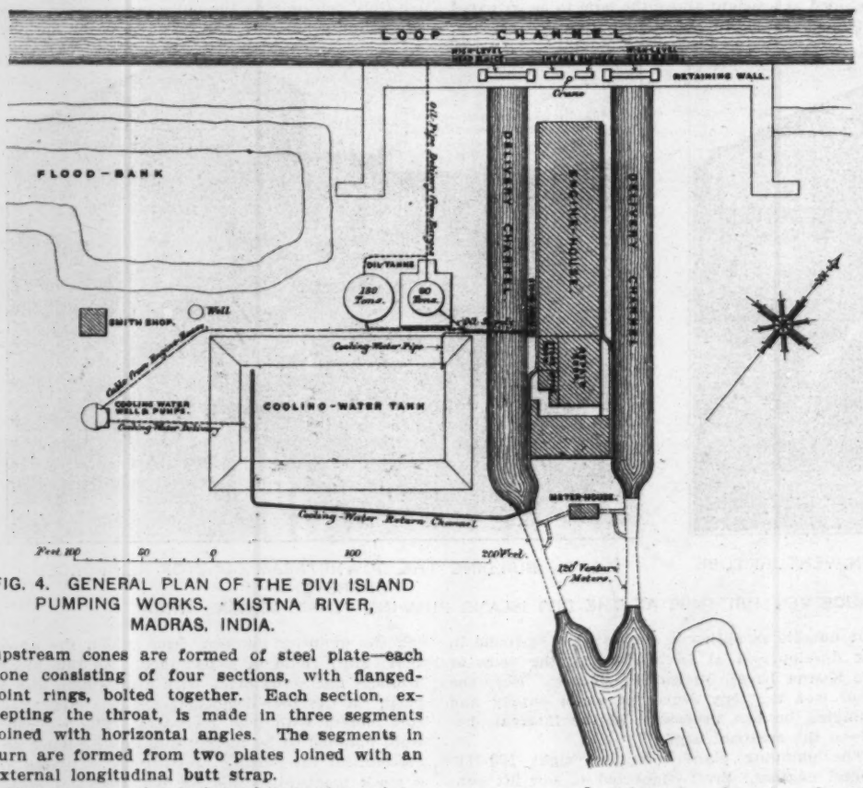


FIG. 4. GENERAL PLAN OF THE DIVI ISLAND PUMPING WORKS. KISTNA RIVER, MADRAS, INDIA.

upstream cones are formed of steel plate—each cone consisting of four sections, with flanged-joint rings, bolted together. Each section, excepting the throat, is made in three segments joined with horizontal angles. The segments in turn are formed from two plates joined with an external longitudinal butt strap.

The throat section is formed from three plates joined together with longitudinal butt straps and with three inner ring bands 3 ins. wide and 1 in. thick, riveted flush and bored to gage. The small annular pressure chamber, around the throat, is formed of 4 × 4 × ⅝-in. angles and of 4 × 2½ × ½-in. channel steel. The whole throat section was made complete in one piece and lined throughout with gun-metal. Access is given to the annular pressure chambers, at the throat and upstream sections by several 1-in. wrought-iron barrels. Those barrels not connected to the pressure pipes, running to the meter house, are capped with brass plugs. The general appearance of the steel work is shown in Fig. 1.

The steel cones were bedded in concrete to give greater stability, and the downstream cone was formed in the concrete, with no lining. Here the concrete is reinforced with expanded metal.

Fig. 2 shows the steelwork, while being covered with concrete and during the building of the downstream cone. In Fig. 3 are disclosed the details herein noted.

The arrangement of the whole pumping plant is seen from Fig. 4. The water is lifted by the pumps from the loop channel, coming from the two arms of the River Kistna, and is delivered into two pump channels which unite at a Y to form the distributing canal. In time of seasonal floods the water level in the loop channel is high enough so that the gates on the pump canals may be opened and the water thrown into the distributing canal without running the pumps.

The Venturi tubes in fact form inverted siphons, the crown of the tubes being below the invert of the channels so that the tubes may be full always, no matter how small is the flow of water. The friction head at various loads is given as follows:

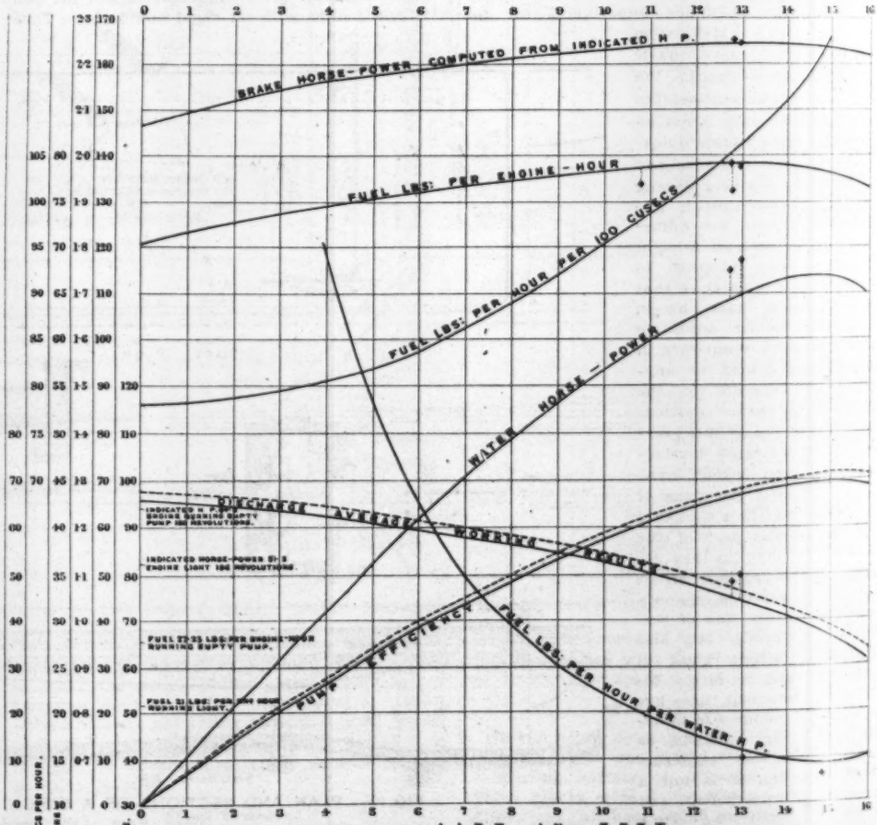
(Maximum)	625 cu. ft. sec.	1.35 ft.
	400 cu. ft. sec.	0.60 "
	250 cu. ft. sec.	0.22 "
(Minimum)	50 cu. ft. sec.	0.00 "

The pumping machinery was supplied by James Simpson & Co., Ltd., of London, E. C., and the Venturi meters were made by George Kent, Ltd., 199 High Holborn, London, E. C., to which firm

Notable Record of a Plant Pumping with Diesel Engines, Divi Island Station, Madras, India.

The pumping plant of the Divi Island irrigation plant, partially described in the preceding article, has now been in operation for two seasons and the results reported have been so satisfactory that the Government has taken over the operation, although under the agreement with the builders, Messrs. James Simpson & Co., Ltd., of London, the latter were to be called on to run it for another year. The efficiency of the pumps and engines has been maintained at a notable high figure.

The consumption of liquid fuel during the past season was 417,338 lbs. for a total of 6,00[illegible] engine hours at an average of 151 B. HP., or [illegible]6,453 B. HP.-hrs. This is at the rate of 0.462 lbs. per B. HP.-hr. The calorific value of the fuel at the beginning of the season was reported to be 18,626 B. T. U. per lb. (The specific gravity is normally about 0.9342. This fuel is known as "Borneo petroleum residue." Some lighter Burma oil of slightly greater calorific value has been successfully tried.) Thus the fuel consumption is figured at about 8,600 B. T. U. per HP.-hr. This gives a thermal efficiency of 29.5%—a figure which may well be considered remarkable, when it is remembered that the maximum thermal efficiency of a Diesel engine ever reported is about 38%, and that under the most favorable test conditions. Common favorable tests show an average of 30 to 35%. This figure of 29.5% represents the average for eight engines running alternately during a short season, for 24 hours a day and two engines at a time. This can hardly include the consumption of two 9-HP. Hornsby-Akroyd internal-combustion oil engines for the auxiliaries. These run two plunger pumps for fuel oil, two vacuum pumps for filling the main pumps, and two centrifugal pumps for circulating the jacket water of the Diesel engines. A small electric-light outfit is run by a third 9-HP. Hornsby oil engine. The main shafts for


BRAKE HORSE-POWER COMPUTED FROM INDICATED H. P.
FUEL LBS. PER ENGINE-HOUR
FUEL LBS. PER HOUR PER 100 CUSECS
WATER HORSE-POWER
DISCHARGE AVERAGE MONTHLY
PUMP EFFICIENCY
FUEL LBS. PER HOUR PER WATER H. P.
LIFT IN FEET.
EFFICIENCY %
FUEL PER 100 CUSECS PER HOUR.
FUEL LBS. PER ENGINE HOUR.
FUEL LBS. PER H. P. PER HOUR.
HORSE-POWER.
DISCHARGE CUSECS.

CHARACTERISTIC PERFORMANCE CURVES OF DIESEL-ENGINE PUMPING UNITS. DIVI ISLAND.

(Note: Discharges registered by Venturi meter. Dotted curves exclude observations known to be below average for definite cause. Spotted points indicate values obtained at official trials. Actual observations taken with lifts of 4 to 15 ft.)

the dynamos and the auxiliary machinery can be coupled together and run by one or all of the Hornsby engines. While the fuel consumption of these auxiliary engines has not been directly stated, computing back from the expense reports shows 19,238 lbs. additional for these or a total of 436,576 lbs. for the season.

The Hornsby engines were run at first on kerosene, but subsequently on the fuel oil (residual petroleum). They acted satisfactorily on the fuel oil so long as the oil was of a high calorific value and low specific gravity and so long as the engine was slightly under loaded. They were fitted with separate vaporizers for the fuel oil as well as with the ordinary kerosene vaporizers. One engine, however, was run through a season with only the kerosene vaporizer. It was necessary then to clean the vaporizer daily. During the last season it was necessary to run only two of the Hornsby engines; one for 24 hours per day and one some 10 hours for the electric lighting. The consumption would be at an average 5.67 lbs. fuel oil per engine hour well loaded.

The accompanying figure was presented in the paper "Pumping by Oil-Engines; Divi Irrigation Works," by Mr. Percy Hawkins, M. Inst. C. E., Deputy Chief Engineer, P. W. D., Madras, India, and was printed in the "Minutes of the Proceedings of The Institution," 1908-9, Part 2. This shows the average of the actual results of the first season's working under all conditions in 1907. The figures quoted above for the past season indicate some improvement.

The Diesel engines were of the latest type of the usual English pattern—having double cylinders, exposed crank pits and crank connections. Trouble was found from the fine sand carried into the power station by the prevalent high winds. It is now stated that in such places where sand storms are frequent, the American pattern with closed crank pits would be preferable.

The centrifugal pumps, as would be expected, are most efficient at about 15 or 16 ft. In the article from which the operating figures are taken, this rating is stated as 81.5% at 16 ft. In Mr. Hawkins' curves the best rating is 71% at 15 ft. The pumps are operated at lifts ranging from 0 to 16 ft., according to the seasonal height of the river and of the water in the loop channel.

In the last season the plant was running light for 24 hours per day for five months, or a total of 6,003 hours. During this time it is recorded that 1,850.63 millions cu. ft. of water were lifted to an average of 8.85 ft. The total horse-power hours being 906,453, the average pump efficiency for the season works out at about 57%. The average duty of one of these pumping units for the season, expressed in foot-pounds per million heat units consumed, is 132,000,000, computed from the data already given.

The operating costs for the past season have been collected in the accompanying table. These results show the expenses during the running season only and include nothing for depreciation and investment charges which should in justice have been included. These data, however, were not available with the others.

TABLE I.—COSTS OF OPERATION, DIVI ISLAND PUMPING PLANT.

SALARIES (5 months).		
Superintendent	3,500 Rupees	$1,680
Asst. Superintendent	1,500 Rupees	720
3 Drivers	2,300 Rupees	1,103
Oilers, etc.	2,250 Rupees	1,080
Fuel oil	7,870 Rupees	3,780
Lubricants	1,400 Rupees	673
Waste and stores	365 Rupees	175
Spare parts	365 Rupees	175
Total for season	19,550 Rupees	$9,386
OPERATING COSTS.		
Per B. HP.-hr.		1.03 cts.
Per million cu. ft. water pumped		$5.06
Per million cu. ft. water pumped, 1 ft.		57.2 cts.

The costs of the table shown, are for five months. During two of the months remaining, when the pumps are not running, owing to high water, full salaries are paid for the period of overhaul. Half the average rate of wages is paid during the five months still remaining. This is stated to being the cost for the whole season up to 28,145 rupees, or $13,450. At present only 16,500 acres are irrigated, the annual cost being then 81.6 cts. per acre. The project when fully developed will irrigate 50,000 acres, which work will tax the capacity of the pumping plant in times of long-continued low water. The cost of irrigation, per acre, will decrease as more land is cultivated, and the cost of developing one brake horse-power year will materially decrease, as the working force of the plant at present is very nearly that required for full loadings. In times of low water the pumps will be working at the more efficient lift (16 ft.), which fact coupled with the other circumstances just noted should result in still more notable records for costs of pumping water.

The figures herein presented are mostly from data printed in the June issue of the "Indian and Eastern Engineer" of Calcutta, and from information supplied by the pump manufacturers, the Worthington Pump Co., Ltd., of London, E. C. A few data are taken from the paper of Mr. Percy Hawkins, mentioned, before. The Diesel engines in this plant were made by Messrs. Carel Frères, of Ghent, Belgium.

Experiments on Conveying Concrete Through Pipes Under Air Pressure.

By J. W. BUZZELL,* Assoc. M. Am. Soc. C. E., and WILLIAM H. LARKIN, Jr., M. Am. Soc. M. E.

The various kinds of machines and devices for measuring, feeding and mixing concrete ingredients are too well known and numerous to require description. Such machines are to be found on

Fig. 1. View of Hopper Tank, Under Compressed Air, Used as the Reservoir from Which to Force Concrete.

all works of any size or importance and have served to reduce the cost of the various operations to a point which makes possible the use of concrete for all classes of construction.

Notwithstanding the wonderful strides made in the reduction of cost and time by the use of machinery for these various operations, mixed concrete is still conveyed into place by the same crude, slow and expensive methods that existed from the first, namely, wheelbarrows, carts, cars, buckets, chutes, etc., requiring enormous proportional outlays for runs, trestles, railways, engines, derricks, and other plant as well as cost of operation and maintenance of same. These crude methods have other marked disadvantages. Concrete handled by wheelbarrows, carts, buckets, etc., is subject to considerable waste and tends to set in transit, particularly where transported considerable distances as is frequently the case. Concrete construction is often from necessity carried on in cold weather subjecting the concrete to the danger of chilling; therefore, any apparatus that conveys the mixed concrete instantly from the mixer into place is particularly desirable.

With the idea of devising some method by which the transportation of the concrete mixture might be simplified the writers of this article some years ago started experiments on forcing the wet mixture through pipes by means of compressed air. The writers were then engaged in the construction of a difficult piece of concrete work where it became necessary to place the concrete by causing it to flow through a long length of pipe placed in an approximately vertical position. It was thought at the time that if the force of gravity would cause the concrete to flow downward through the pipe, there was reason to believe that concrete could be made to flow through a pipe in any position when acted upon by some force other than gravity, such as steam or air pressure.

This conclusion was not arrived at until considerable experimenting along other lines had been

Fig. 2. Stream of Concrete being Forced from End of 4-in. Pipe.

done. The first trials were made by attaching the suction end of a large centrifugal pump to the discharge end of a concrete mixer which scheme proved to be a failure, due to the fact that the stone separated from the sand and cement and discharged separately. The first encouraging results were brought about by attaching a large steam pipe to the pump casing, thereby introducing a pressure into the body of the pump which acted upon the mass of concrete in it, causing it to discharge in a more satisfactory manner. These experiments led to the design and trial of a cylindrical receptacle provided with a sealable opening at the top for the admission of mixed concrete, a discharge pipe and valve at the lower end and means for introducing pressure at the top. The discharge pipe at the lower end led to the place where the concrete was to be deposited. Upon applying pressure the concrete was instantly forced through the pipe and deposited in the same condition as when introduced into the receptacle. Many minor difficulties were encountered during the experiments, which, however, were overcome and patents were secured on the process and apparatus.

In order to obtain necessary engineering data, other more elaborate experiments were conducted using the same type of apparatus and covering a period of several months, during which the photographs reproduced in the accompanying halftones were taken.

The device used in the experiments consisted of an iron tank (Fig. 1) provided at the top with an air-tight gate, on the side with a pipe entrance

Fig. 3. Velocity-Reducing Nozzle Used in Experiments on Compressed Air Transmission of Concrete. Pressure, 80 Lbs. Per Sq. In.

(This ½-cu. yd. batch of broken stone concrete was deposited at the end of the 400-ft. 4-in. pipe line in less than 5 seconds from the time of applying pressure in the receiving chamber.)

for the compressed air and at the conical bottom with an exit pipe for the concrete. Concrete was first mixed on a board at the top of the hopper and poured into the tank through the upper gate which was then battened tight. Simultaneously,

*507 Park Ave, East Orange, N. J.

then, valves on the intake air pipe and the outlet concrete pipe were opened and the compressed air forced the concrete out of the tank through a 4-in. pipe, to the point of exit. The 4-in. pipe used to transmit the concrete was about 400 ft. long and contained several 90° bends and one 180° bend around a 4-ft. radius. There seemed to be no obstacle to the use of a much longer pipe had it been convenient at the time and place.

Tests were carried on with air pressures up to 100 lbs. per sq. in., but it was found that 50 lbs. was the most efficient. Under this pressure the concrete mixture was forced out of the end of the pipe in a well-mixed mass, but at a velocity too great for practical work (Fig. 2). To reduce this velocity a nozzle, such as shown in Fig. 3, was devised. This is simply a plank box with a curved upper cover which diverts the fast-moving stream of concrete and drops it, thoroughly mixed, on the ground or, on actual work, within the forms.

The concrete was hand mixed, of 1:3:5 proportions, and was made with stone up to 2-in. diameter. About as much water was used as in ordinary reinforced-concrete work, that is, it was a fairly wet mixture.

The main object of these experiments was to determine the amount of power necessary to convey concrete through pipes of different sizes and lengths; and the coefficient of friction between the concrete and the pipe so as to make possible the use of Bernoulli's Theorem in the design of other apparatus.

Inasmuch as during experiments concrete was deposited without difficulty at a height of about 100 ft. above the mixer through a vertical pipe line it is reasonable to assume that it can be conveyed by this means to any height that would be encountered in ordinary construction.

The process of making concrete resolves itself naturally into several separate and distinct divisions, namely; manufacture of cement, the handling of cement, sand and stone, measuring, feeding and mixing the aggregates, conveying and placing the concrete. The invention of the rotary kiln, and numerous devices for measuring, feeding and mixing the aggregates, has reduced the cost of concrete to a point where it is now used on all classes of construction. It is a fact, however, that concrete is still conveyed and placed by the same crude and expensive means that were in use from the beginning. Inasmuch as the greatest factor in the present cost lies in the conveying and placing of the concrete it would seem that these experiments in pneumatic conveying offer a solution of the problem of still further reduction in cost, as statistics obtained during these experiments show that on works of even moderate magnitude concrete can be conveyed by pneumatic means for less than 10 cts. per cu. yd.

THE BATTLE RIVER VIADUCT of the Grand Trunk Pacific Ry., 675½ mi. west of Winnipeg, completed in December, 1908, is a steel plate-girder viaduct 2,772 ft. long between abutments and 184 ft. high from base of rail to low water, or about 139 ft. average height above ground. It comprises a 150-ft. deck truss span crossing the main part of the river channel, one 70-ft. plate-girder span and 51 50-ft. plate-girder spans, resting on 26 steel towers. Thus the tower spans are of equal length with the intermediate spans, i. e., 50 ft. The substructure is of concrete, the two river piers and most of the land footings being founded on piles. ["Railway and Marine World," Toronto.]

Lining and Grouting a French Railway Tunnel in Water-Bearing Material.

In the construction of tunnels through water-bearing material difficulties are usually encountered in preventing the entrance of water through the lining, and an interesting piece of work of this kind has been described by Mr. E. Nivert, Engineer of the Paris, Lyons & Mediterranean Ry., in the "Revue Generale des Chemins de Fer."

THE TUNNEL.—The tunnel in question is on the line from Fayet to the Swiss frontier, and pierces the ridge known as the Col des Montets. It is 6,170 ft. long (including 164 ft. of covered gallery). The track summit is 4,546 ft. above sea level, and the mountain rises 1,312 ft. higher. The tunnel has vertical side walls, and a semi-circular roof arch, the height from rail to crown being 16.40 ft. The width is 19.68 ft., accommodating a sidewalk 4 ft. wide, which is separated from the railway by a masonry wall. The center of the track is offset 22 ins. from the center of the tunnel.

The materials encountered included mainly mica-schist and quartzite, with some gneiss and glacial drift. The rock strata are but little inclined from the vertical, and are full of seams and faults which extend to the surface and are intersected by the tunnel. Numerous springs also were struck by the headings. Under these conditions the amount of water to be dealt with was very great. The flow varies with the weather and increases to a very large amount when the snow melts on the mountains.

LINING.—The tunnel is lined throughout with masonry, the thickness varying from 16 ins. in solid rock to 32 ins. in wet or soft material. On the first part of the work the lining was 16 ins. thick, and in solid rock it was built against the line of excavation, without stone backing, as shown at (A) Fig. 1. In water-bearing material, the lining was given an outer coating of coal-tar, protected by a coat of cement mortar, and over the arch was a 12-in. backing of dry stone to provide for drainage, as at (B) Fig. 1. Behind the side walls inclined benches were cut in the rock, forming a series of Vs, with a weep hole or lateral drain at each low point. These drains were 16.4 ft. to 32.8 ft. apart, and led to a central box drain on the floor of the tunnel. The bench was plastered with cement mortar to facilitate the flow of water, and dry stone backing was filled into the triangular space from the drain to the springing line. In some cases the entire space behind the side walls was excavated for a 12-in. dry-stone backing, which rested on a masonry base behind the footing, and formed a series of grades to the drains; this is shown at (C) Fig. 1.

In May, 1906, when the arch lining had been built for 850 ft., the rains and the melting of the snow under a warm wind increased the inflow of water to such an extent as to exceed the capacity of the weepers. The water accumulated over the arch and behind the walls, and its pressure was sufficient to distort the lining, displace the backing and force openings in the joints of the masonry. In the heading at the Martigny end (in soft material) the torrents of water caused several slips.

New designs of lining were then adopted, with the 32-in. masonry arch and walls. To resist the thrust of the arch, masonry ribs or blocks were built at the springing line, extending back against the rock. The top surface was sloped to weep holes at the springing line, and the flow from these was carried down the inner face of the tunnel by pipes, and discharged into a box drain on each side, instead of the original central drain. The sidewalls and footings were reinforced by masonry buttresses or counterforts 3.28 ft. wide and 16.4 ft. apart. Two sections of the new construction are shown at (D) and (E), Fig. 1.

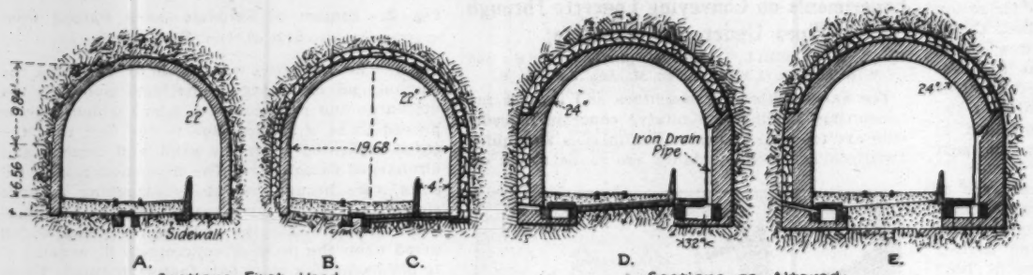


FIG. 1. SECTIONS OF LINING OF TUNNEL REINFORCED BY GROUTING.

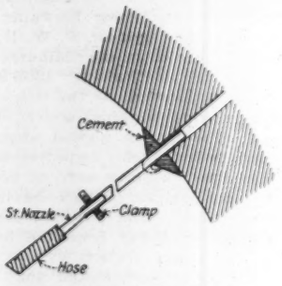


Fig. 3. Nozzle for Grouting.

GROUTING.—In order to prevent the continuous leakage through the lining already built, and to reinforce that lining, it was decided to inject cement grout to fill the voids in the stone backing. The grout was composed of 110 lbs. of Portland cement to 10 gallons of water. The mixer, Fig. 2, was a horizontal cylinder, with a charging door (A) and a discharge pipe (B) fitted with a valve; a central shaft with paddles (C) was driven by hand by means of a crank handle. This apparatus was set on frames and connected to the main air-pipe for the drills by means of a flexible hose, attached to the mixer tank at (D). A larger length of hose was fitted to the discharge pipe. An auxiliary air pipe (E) led from the tank connection to a point beyond the valve in the discharge pipe. This enabled air to be blown through the hole in the lining, to drive back the water before the grouting was forced in. The general arrangement of the apparatus as applied to the old and new lining is shown in Fig. 4.

The hose for grouting had a steel nozzle, to which was clamped a piece of lead pipe 6 ft. to 9 ft. long. This pipe was inserted about 4 ins. into the hole, and sealed in place by a patch of quick-setting cement, as shown in Fig. 3. Com-

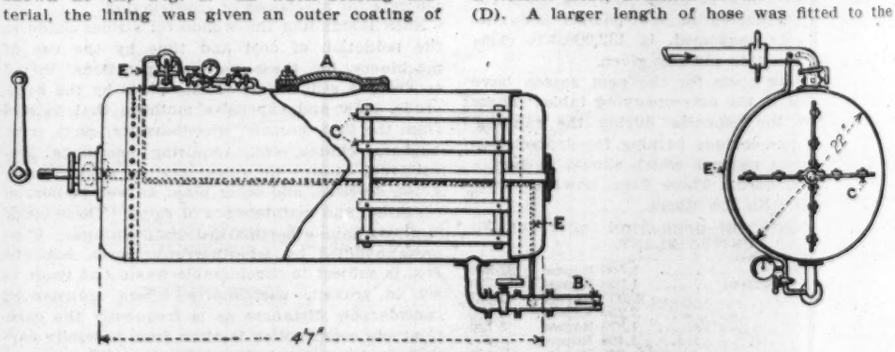


FIG. 2. AGITATOR FOR MIXING CEMENT GROUT.

pressed air was then admitted to drive back the water, some of which escaped through the joints and the weep holes. These holes were then plugged with sacks, tightly rolled. The air valve (D) and discharge valve (B) were opened, and the air pressure forced the grout through the pipe into the spaces behind the tunnel lining. A whistling noise notified the operator that the tank was empty, when the valves were at once closed. While the next charge was being mixed, the lead pipe was cut off and hammered over to close the end, thus preventing the escape of grout, as shown by dotted lines in Fig. 3.

The grouting was commenced usually at the lower holes (6 ft. above the floor), and ended at the crown; in some special cases, where the grout had to travel long distances, the work was commenced at the crown.

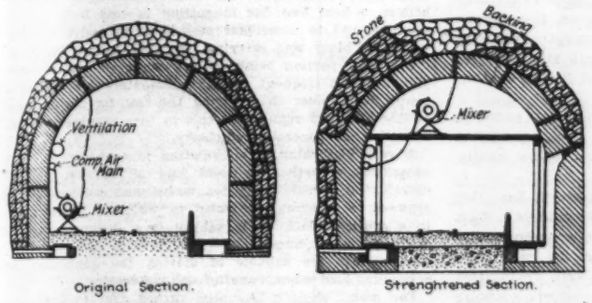


FIG. 4. ARRANGEMENT OF APPARATUS AND HOLES FOR GROUTING.

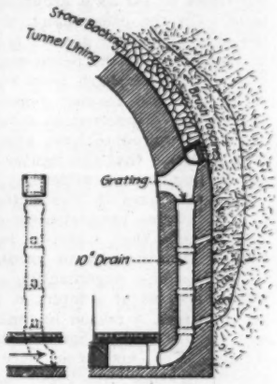


Fig. 5. Backing and Drain in Very Soft Ground.

At the Chamonix end of the tunnel, work was commenced at the first ring without backing (A, Fig. 1). Here the grout was injected until no more could be forced in, thus forming a barrier beyond which the water could be driven back by the progress of the grouting. The work was then continued towards the portal until a fault was met which led to the surface of the ground. The apparatus was then moved to the portal, and the work advanced inward until the water entering by the fault was sealed between two barriers of cement. As a good deal of water still appeared at the weep holes at this point, it was evident that much of the grout was being lost. The grouting was continued therefore at the three holes in the crown, the pressure being reduced, so that the grout would collect and seal the backing at the haunches.

The heavy rains of May and June, 1907, showed that grouting was required also for the heavier type of lining. In this case, as the backing of the arch and side walls was separated by the rib of masonry, the grouting was done first at the crown, the weep holes at the springing line being plugged. At very soft places, the grouting was done so as to form a barrier on either side, and thus prevent the spreading of water during rains or when the snow was melting. The grouting behind the side walls was facilitated by the vertical counterforts, which formed compartments limiting the flow of the grout.

The Martigny end of the tunnel is in very soft loose ground, which is covered with snow for six months. Fig. 5 shows the style of backing and drains. In June, 1907, the rush of water from the rapid melting of the snow by a sudden spell of mild weather caused considerable damage. The stones of the backing were displaced (with considerable noise), the lower drains were choked with sand and the water spouting from the upper weep holes (not yet fitted with their pipes) fell against the foot of the tunnel wall on the opposite side. The arch centering was hurriedly replaced. After a study of the conditions it was decided to grout the backing in such a way as to absolutely close all spaces (including back drains and weep holes), so as to form a solid concrete envelope, compelling all water to seek new outlets through the soft soil. In some cases two machines (or even three) were used simultaneously at adjacent holes to prevent the washing away of the grout. The holes were about 10 ft. apart, lengthwise of the tunnel.

This work was done at the end of the summer of 1907, when the snow had disappeared and the flow of water was consequently at a minimum.

A somewhat similar system, for the repair of an old tunnel was described in our issue of Oct. 11, 1906. In this case, however, no compressed air main was available and a more elaborate plant was required. A traveler was used, equipped with two agitators and an air compressor driven by a small steam engine.

It is suggested by Mr. Nivert that the grouting system (so far employed only in emergency) might be adopted during construction when the quantity of water encountered shows the necessity of providing for drainage in the tunnel. Instead of leaving space for a 12-in. backing of stone, a 2-in. space may be left, and the arch coated with tar. A rib on the outside, at the springing line, would separate the space above the arch from that behind the walls, and transverse ribs at intervals of about 20 ft. (filled in close against the rock roof) would divide the space into sections. Temporary weep holes would be provided at the springing and footings. As the masonry progresses, the grouting would be done by suitable apparatus. In this way the tunnel would be reinforced, and the necessity of providing for drainage (as with dry stone backing) will be avoided, the water being forced to seek other channels of escape.

The Pumping of Cement Grout Into Masonry on the Metropolitan Railway, Paris.

In the construction of the Metropolitan Railway, a subway, in Paris, France, there were a number of locations where it was found necessary to pump cement grout behind the tunnel walls, either to strengthen the arch or to fill up holes unavoidably left in construction. The work was of considerable extent and a number of methods were pursued and experiments made in the search for the most efficient scheme. These are discussed in an article in the "Annales des Ponts et Chaussées," July-Aug., 1909, by M. Suquet, who was connected with the work. From this article we have abstracted some notes that may be of value to American engineers.

APPARATUS.—In general this work was carried on with pumps worked by hand. Really they should have been mechanically operated pumps, but certain conditions made this impossible, in most places. Pumps in which the piston is in contact with the grout are not adapted to this use because they wear out very rapidly, and in place of them was substituted a hand air compressor with a double piston, which compressed the air in a cylinder containing the grout, from which it was driven by pressure through a flexible tube into the masonry. A paddle continually revolving inside the cylinder mixed the grout and kept it from setting during the operation.

On parts of the work power machines were used. In one of the most important of these, the air compressor, 7 ins. in diameter, driven by an electric motor, feeds a reservoir 20 ins. in diameter and 60 ins. high, which in turn leads into the grout cylinder. The reservoir is separated by a valve from the grout cylinder so that compressing can go on while the cylinder is being filled. The mixing of the grout in the cylinder is mechanically continued during the operation of pumping. The whole apparatus is mounted on a truck and may be moved easily from one part of the tunnel to another. With this machine it was possible to inject 12 tons of solid cement and sand in 10 hours of work.

Although the machine is quite satisfactory in some of its details, it presented certain difficulties. The main one of these was its poor mechanical construction, which necessitated its frequent repair. Also it took considerable time to charge the cylinder every time it was opened. It was necessary, in fact, to take off a lid held down by three bolts, and fill it by means of pails of concrete mixed on the outside, and then to replace the top and rebolt it on. Finally, it was very heavy and cumbrous. On this account several new apparatuses have been designed. The one represented in Fig. 1, designed by one of the contractors on the work, is composed of a centrifugal pump driven by an electric dynamo drawing the grout by a tube t, from a tank B, and then taking it as shown on the cut through a tube t_2 into the masonry. Thanks to the high speed of the pump (1,500 r. p. m.), the pressure attained was 45 lbs. per sq. in. The originality of this apparatus consisted in the fact that in place of mixing the grout by hand—a long and difficult operation always—it was possible to

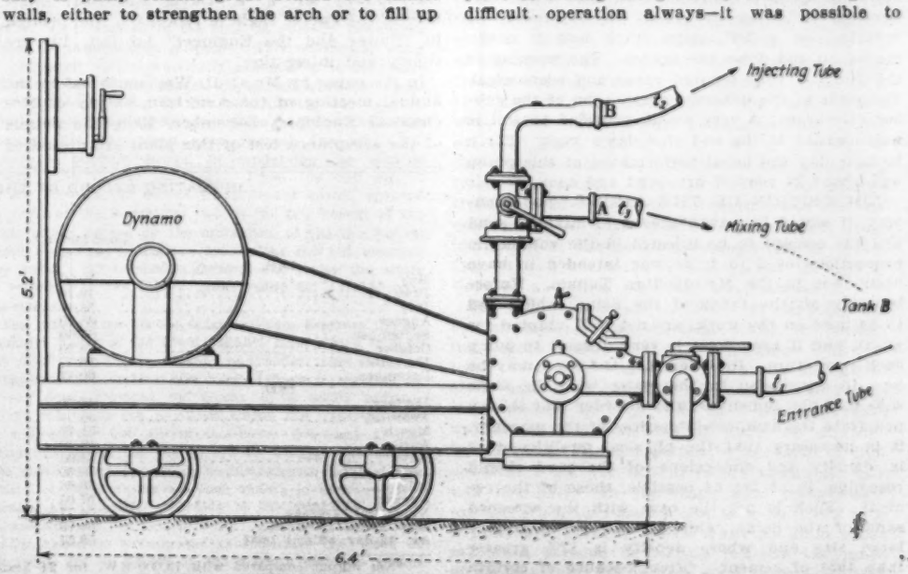


FIG. 1. CENTRIFUGAL PUMP USED TO PUMP GROUT ON METROPOLITAN RY. TUNNEL, PARIS.

place in the tank *B* the water, cement and sand without mixing it at the beginning; then, on starting the pump, shutting off tube t_3, the mixture would follow the line t_2 t_1. After several revolutions through this path, the mixture of the sand, cement and water would be perfect. It was possible with this machine to inject in 10 hours of work 10.4 tons of material. The trouble with the device is the extremely rapid wear of the shaft of the pump.

The last machine used, and one which gave the best satisfaction of the lot, was the one shown diagrammatically in Fig. 2, devised by M. Buignet, an engineer in the Ponts et Chaussées. This is a pump designed for pasty material in which the interior is divided into two parts by a rubber membrane which can move under pressure as far as the cast-iron gratings shown. On one side of the membrane is clear water, which can be expanded or compressed by the piston, and on the other side is the cement grout kept in place by ball valves. Under impulse of the piston the membrane moves back and forth and thus forces the grout up through the chamber

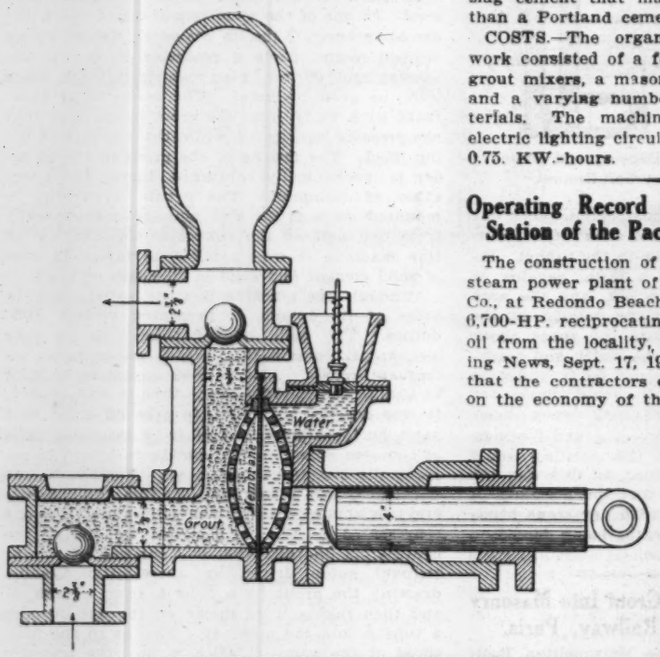


FIG. 2. SECTION THROUGH THE BUIGNET GROUT PUMP.

into the grouting pipe, its pressure being regulated by the reservoirs shown. The whole apparatus, including the small electric motor, is mounted on a 2-ft. gage track and is easily moved up and down the tunnel. The working of the pump is very regular, rapid and economical. The wear of the different parts, even of the rubber membrane, is very small, provided that it is well cleaned at the end of a day's work. For a 10-hour day the usual performance of this pump was about 24 tons of dry sand and cement.

COMPOSITION OF THE GROUT.—For economy, it would be advantageous to mix the sand and the cement to be injected in the volumetric proportions of 2 to 1, as was intended to have been done in the Metropolitan Tunnel. Unfortunately all the sands of the Seine, which had to be used on the work, are not well adapted for grout, and it sometimes is very difficult to pump such a mixture. In order that the sand may be held in suspension by the water with the same ease that the cement is, and in order that it may penetrate the smallest interstices of the masonry, it is necessary that the physical qualities—that is, density and dimensions—of the sand should resemble, in so far as possible, those of the cement. Such is not the case with the screened sand of the Seine, which is always of a very large size and whose density is 12% greater than that of cement. Often, because of certain difficulties which affected the use of these sands, the injections were made with pure cement grout.

M. Buignet has recently made a series of experiments on different fine sands. He found that sand with a density only 81% of that of cement and which leaves 5.5% of its volume on a screen with 900 meshes to the square centimeter (a 75-mesh in the inch measurement) and 75% of its volume on a 4,900 (180-mesh in inch measurement) screen, gave excellent results. With the pump which he invented and which is described above, he succeeded in injecting not only a grout of such sand with cement but even sand. In a test pouring this sand-cement grout ran about ten times as far as a grout made with the Seine sand. On the other hand, the mortar made of the sand of smaller density is inferior in strength to that made of the Seine sand. At 14 days the latter had a strength from twice to seven times as great as the former, depending on the degree of mixture. However, as a rule, grout injections are not required to have any great strength, so it is probable that the lighter sand is the best to use in pumping operations.

In some cases it was found that on account of the extreme unctuousness of a grout made of slag cement that material pumped more easily than a Portland cement grout.

COSTS.—The organization necessary for the work consisted of a foreman, an engineman, two grout mixers, a mason to tend the grouting tube and a varying number of laborers to cart materials. The machines were driven from the electric lighting circuit and consumed each about 0.75. KW.-hours.

Operating Record of the Redondo Power Station of the Pacific Light & Power Co.

The construction of the interesting 15,000-KW. steam power plant of the Pacific Light & Power Co., at Redondo Beach, Cal., a plant having three 6,700-HP. reciprocating engines and burning fuel oil from the locality, was described in Engineering News, Sept. 17, 1908. It will be remembered that the contractors earned a bonus of $363,310 on the economy of the station by a 15-day test. The corrected test report showed a record of 252.84 KW.-hrs. per bbl. of oil, the equivalent of 24,438 B. T. U. per KW.-hr.

Reports have gained circulation that the economy of the station had badly fallen off during its operation, so that figures for 16 months of operation (furnished by Mr. C. R. Weymouth, of the contractors for the plant—C. C. Moore & Co., and by Mr. F. R. Davis, Electrical Engineer of the Pacific Light & Power Co., and printed in "Power and the Engineer" for Oct. 19) are timely and interesting.

In the paper by Mr. C. R. Weymouth before the annual meeting of the American Society of Mechanical Engineers December, 1908, the details of the acceptance test of this plant are presented and the uncorrected values of data for that test, in the accompanying table, have been computed back from Mr. Weymouth's figures. Correcting the 220.59 KW.-hrs. per bbl. oil, given in the table, as was done with the original data, according to the contract this is increased to about 236.5 KW.-hrs. The test figure is equivalent to a consumption of 24,438 B. T. U. per KW.-hr. produced at the switchboard. The operating figure is equivalent to about 26,100 B. T. U. The table does not show corrected economies.

It is stated in the article quoted that the monthly records given are under all the exigencies of a station furnishing current for a railway and lighting load, involving a peak load greatly exceeding that handled during the official tests, a slight falling off in the engines at overload, a loss due to inevitable scale in boilers, a heat loss due to cutting in cold boilers after cleaning and to occasional periods of excessive standby while the plant was carrying less than its regular load, the greater portion being on the connected water-power plants. It is frequent that the generators are run at a poorer load factor than during the test for the purpose of line and load regulation, this in turn causing a slight reduction of generator efficiency.

A very disturbing factor relating to economy was the occasional reduction or total loss of vacuum due to clogging of circulating-water mains and condensers by seaweed, a practical difficulty to which a beach plant in a southern latitude is subject to a degree to which engineers upon deeper and cooler waters are strangers. The engines are capable of driving the generators at maximum load when running non-condensing.

The plant, since it has been turned over to the company, has not suffered a single interruption due to failure of the engines, notwithstanding the fact that there is no reserve capacity except the inherent reserve. (There are four cylinders to each engine with a probability of damage to but one cylinder at a time, and with the possible operation of the unit with the remaining three.)

The practical immunity of damage from water in the cylinders was demonstrated, in the early days of breaking in the station, when water was carried through the piping in quantities, owing to an improper connection to the superheater within the boiler. During this short period the engines were run practically on suds. The gridiron valves lifted to relieve the cylinders, the engines groaned a little, water shot out of the piston-rod packings in streams but the engines kept at work.

MUNICIPAL SKATING RINKS above distributing reservoirs of the water-works of Reading, Pa., are to be provided. How this came about is thus explained in a note to this Journal by Mr. Emil Nuebling, M. Am. Soc. C. E., Superintendent and Engineer of the Reading Water Department:

In connection with the construction of filtration plants for the water-supply of the city of Reading, Pa., the present low-service distributing reservoirs will be used as filtered-water basins and are being covered with semi-circular groined arches of concrete, supported on concrete pillars. The reservoirs being centrally located at the head of the main street, and nearly surrounded by the city park, it was decided to put the reservoir covers to some practical use. The suggestion of placing a concrete pavement over the space above the filling on top of the groined arches for the purpose of roller skating was adopted. A shelter is to be erected in the center of each pavement. Concrete curbs, 6 ins. high, will be placed around each pavement so that they can be flooded during the winter for ice skating.

Mr. Nuebling states further that when the filtration plants now being built are completed, all the water supplied to Reading will be filtered, save that from two very small springs which does not need filtration.

OPERATING RECORD OF THE REDONDO POWER STATION.

	Load factor,* per cent.	Station record uncorrected.† KW.-hrs. per bbl. oil.	Station record uncorrected.† Lbs. of oil per KW.-hr.	Special conditions other than load factor influencing plant economy.
1908.				
May	50.90	216.10	1.55	Occasional loss vacuum.
June	49.10	212.60	1.57	Frequent loss vacuum.
July	53.40	228.13	1.46	
August	63.20	216.45	1.54	Occasional loss vacuum.
September	66.60	224.04	1.49	
October	53.20	214.21	1.56	Firing cold oil.
November	53.20	219.60	1.52	
December	60.11	225.08	1.48	
1909.				
January	47.80	209.68	1.59	Frequent loss vacuum.
February	56.54	210.25	1.59	Frequent loss vacuum.
March	51.73	222.89	1.50	
April	48.40	222.29	1.50	
May	53.00	227.41	1.47	
June	50.69	221.68	1.51	
July	56.68	228.88	1.46	
August	57.05	230.12	1.44	
Numerical average	54.77	220.59	1.51	
May 21-22, 1908‡	59.79	224.80	1.49	
Av. 15-day official test§	59.57	235.84	1.42	

*Net output compared with 15,000-KW. for 24 hrs. per day.
†Based on net KW.-hrs. sold and on total bbls. oil purchased.
‡Official 24-hr. test, complete plant.
§On one 5,000-KW. unit, without circulating pump.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
SAN FRANCISCO: Monadnock Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
Z. P. MARUYA & CO., Ltd., TOKYO, JAPAN

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Entered at the New York Post-Office as Second-Class Matter.

The recent terrible disaster at the St. Paul coal mine in Northern Illinois and the rescue of some of the imprisoned miners after eight days of confinement underground ought to call attention to the need of providing two independent openings for the entry of mines of large size. The advantages of independent shafts are well recognized by mining engineers; but it is admittedly difficult to secure the construction of an additional shaft as a safety measure alone. In the development of a large mine the time usually comes when the provision of an additional shaft or other independent entry will give economies in the way of ventilation, drainage or haulage sufficient to make its construction profitable. With such an object lesson as that at Cherry, however, mine owners ought to be more ready to anticipate needs of economical operation and provide additional entries as a safeguard to their employees and their property.

There is undoubtedly a strong prejudice in the engineering profession against laying concrete under water. Millions of dollars are spent every year on cofferdams and caissons, in order to lay foundation concrete in the dry. Notwithstanding this, it is entirely possible to lay concrete under water which will be as sound and solid as the best concrete laid in the open air.

As our readers will recall who have followed the construction of the Detroit Tunnel, a large amount of concrete has been deposited around the submerged steel tubes. We recently examined a core from this concrete, which had been taken to determine its quality. The core was as sound and solid as a natural conglomerate rock. Tests of samples of this concrete have shown a strength as high as or higher than the best specimens of concrete laid in the open air. This concrete is deposited through a tremie, or long tube with its upper end in the open air a considerable distance above the water surface, and its lower end at the point where the concrete is to be laid. Concrete put in place by such methods is forced in under a pressure far greater than is possible with any hand ramming ever used. There is no space for voids and no opportunity for the entrance of air. Furthermore, the concrete is never dried out in the process of hardening, and has always available all the water that it needs for its final set. These reasons are all of importance in explaining the high quality of concrete laid in this way.

Of course "one swallow does not make a summer," and to offset this case, plenty of examples can be quoted where concrete has been laid under water with very disappointing results. But it all depends on how the work is done and the conditions under which it is carried on. Cases like that at Detroit deserve the attention of engineers as showing that there are alternatives to the construction of expensive cofferdams and pneumatic caissons. It is entirely possible that by more intelligent work in laying concrete under water, the cost of many pieces of submarine foundation work could be greatly reduced.

Some of our readers may remember, in the early days of the application of electricity to street railways, the curious scheme of a French engineer, who built what became known as the Heilmann locomotive. We termed it, at the time, an electric "power station on wheels." The locomotive carried a boiler and a stationary steam engine driving an electric generator which furnished current to electric motors on the driving axles. The great losses of power in transformation and the expense and complication of the machine promptly relegated it to the category of mechanical curiosities.

A curious attempt to revive this old idea is being made in Scotland, and more or less has been published concerning it in American newspapers recently. A description of the system is given in "The Engineer" of London of Nov. 5, taken from a presidential address delivered by Mr. Hugh Reid, the inventor of the scheme, before the Glasgow University Engineering Society on Oct. 28. We quote our contemporary's description as follows:

Steam is generated in a boiler of the ordinary locomotive type, which is fitted with a superheater, and the coal and water supplies are carried in the side bunkers, and side water-tanks at both sides of the boiler. The steam from the boiler is led to a turbine of the impulse type running at a speed of 3,000 r.p.m., to which is directly coupled a continuous-current variable voltage dynamo. The dynamo supplies current and pressures varying from 200 to 600 volts to four series-wound traction motors, the armatures of which are built on the four main or driving axles of the locomotive. The exhaust steam from the turbine passes into an ejector condenser, and is, together with the circulating condensing water, delivered eventually to the hot well. As the steam turbine requires no internal lubrication, the water of condensation is free from oil, and consequently is returned from the hot well direct to the boiler by means of a feed pump. The water evaporated by the boiler is therefore returned to the boiler again and again, and the supply of water carried in the tank is actually circulating water for condensation purposes. This condensing water is circulated within practically a closed cycle by means of small centrifugal pumps driven by auxiliary steam turbines placed alongside the main turbine and dynamo. The cycle of the condensing water is from the tanks through the first pump, then through the condenser, where it becomes heated in condensing the exhaust steam, then to the hot well. From the hot well it passes through the second pump to the cooler, situated in front of the locomotive, where the full benefit of the blast of air caused by the movement of the locomotive, aided by a fan, is utilized for cooling the hot circulating water. After passing through the cooler the water is returned to the supply tanks ready for further condensation.

The condensation of the exhaust steam deprives the locomotive boiler of the usual exhaust blast which induces the draft through the fire-box and boiler tubes. In the experimental locomotive the induced draft is replaced by forced draft provided by means of a small turbine-driven fan. The fan is placed within the cooler so that it will deliver hot air to the boiler fire, and at the same time assist the current of air through the cooler. The small switchboard and the instruments required, the controller for grouping the four motors in series—series-parallel and parallel, according to the draw-bar pull to be exerted—and the regulator for controlling the voltage in the electrical circuit, and consequently the speed of the train, are all placed on the driver's platform within easy reach.

The foregoing comprises the main and auxiliary machinery of this experimental locomotive. The whole is mounted upon a strong underframe, which is carried upon two eight-wheeled compound bogies so constructed that they will easily negotiate curves. Each bogie carries two of the four driving motors already referred to. As the engine is intended for express passenger main line work, it is hoped to obtain comparisons from its actual working with the performances of the reciprocating steam locomotives, especially as regards the relative consumption of fuel and water, and also as to the efficiency of transforming the energy of steam into draw-bar or train pull, as well as the relative rapidity of acceleration under the old and new systems.

Most of the component parts of this steam turbine electric locomotive have already proved themselves effective and efficient in other applications, and the novelty lies in the combination of the different elements of which the locomotive is composed. The expected results in this case should not, therefore, be so problematical as in an invention where the novelty is in the details, and it is the question of the cost of the locomotive which most troubles the patentees or raises any doubt as to its free adoption. It is only when the attempt is made to substitute an electric for a steam locomotive that we realize at what a very moderate first cost the steam locomotive can now be produced in up-to-date establishments with modern machinery and scientific organization in comparison with any arrangement involving the use of expensive electrical apparatus.

To say nothing about the first cost of this extraordinary concatenation of machinery, it will be agreed, probably, that a steam turbine of the type described, running with the enormous variations of load to which it would be subjected, will consume almost certainly considerably more steam per horsepower hour than the cylinders of the ordinary steam locomotive. The electric generator will probably have an efficiency of not over 80% running under such a variable loading, and the same efficiency will apply to the electric motors. If these efficiencies are accepted as fair, it will be apparent that only 64% of the power developed by the steam turbine will be applied to the propulsion of the locomotive. This loss in efficiency is even more important in its effect on the power of the machine than upon its fuel economy.

As for the other revolutionary mechanical ideas, such as the cooling of the condensing water by air circulation within the limits available on a locomotive tender, and the use of a fan to furnish draft for a fire-box—both these are so unpromising on their face as to make safe the prediction that the Reid locomotive will have no more influence on railway practice than did the Heilmann.

Some months ago we published an editorial criticism of the reinforced-concrete truss in which among other things, we called attention to the great uncertainty regarding the amount and disposition of stresses in this new type of bridge. In the present issue this opinion is confirmed in the description of the design of what are probably the largest reinforced-concrete trusses built in this country, those on the Broadway or Sparkman St. Bridge, at Nashville, Tenn. From this article it will be seen that the theoretical investigations of the stress conditions in the truss were most general and unsatisfactory and that credence was placed in its design mainly because of the excellent performance under load of a model of the truss reduced to 1-10 linear and 1-100 sectional dimension. Without doubt this smaller truss showed remarkable strength under the excessive load to which it was subjected, and as an indication of the possible strength of its prototype it had considerable utility, but its limitations as a method of design are marked.

The fallacy of small size tests for anything but the strength of the material itself is becoming more and more recognized. Theoretically, strength ought to be proportionate to size, and for perfectly homogeneous bodies it probably is, but for the ordinary built up member of construction made of a number of pieces joined together by cohesion or mechanical bond, the law of direct proportionality will not hold. In the large steel compression member this discrepancy has been so great that it has been thought worth while to build great machines capable of testing full-size the units of all but the very largest steel bridge. If this has been found necessary for the steel strut, which can be imitated in miniature in nearly every detail of material and construction, how much more necessary should it be for a concrete

truss made up of diverse members and a heterogeneous material.

Practically all tests that have been conducted on reinforced concrete have been on full-size beams and columns. The behavior of these test pieces may be accepted as an accurate reproduction of that of the unit in the structure, because the size is about the same, the distribution of loads are similar and the stress conditions are simple. The test truss used at Nashville is different. The section proportion was 1 to 100, the loadings were only approximately similar and the stress conditions were complicated on account of the peculiar non-diagonal type of truss. Of these three differences, that in size is of the most importance. Exact reproduction, in reduced scale, of the reinforcement could hardly have been possible, because such reduction would require wire of the most minute section. Consequently, the bonding value of the reinforcement in a small-size replica of such a truss bears no proportional relation to the dimensions. Again, the concrete placed in a 10.5 ft. truss with 3½ × 4-in. members is not the same material as that placed in a 105 ft. truss with 36 × 40-in. chords.

We emphasize these facts not to prove the inaccuracy of the small size test as used here but to show its uncertainty. It may be that the small truss acts in precisely the same manner as the larger, but we have no way of knowing that and the evidence, purely theoretical, is to the contrary. Therefore, the high efficiency of the model is not verification of the strength of the original, but is only what might be termed a "predisposing tendency" toward that verification. And since the theory of stresses in the truss is admittedly shaky the whole construction is on a rather insecure foundation as far as knowledge of its possibilities go. That it is not strong enough we would not for a moment venture to affirm; just how strong it is we doubt if any one can tell.

The longest masonry span in the world has once more appeared, this time a 320-ft. three-hinged reinforced-concrete arch in far-off New Zealand. On account of its antipodean remoteness, news of its construction did not come to this office until too late to place it at the head of the list of "Masonry Arches Over 175-ft. Span" in our issue of Sept. 2, 1909, so we take this opportunity of giving it due credit. The bridge in question—the Grafton Bridge, now being completed by the city of Auckland—is 910 ft. long and 40 ft. wide and the middle arch has a span of 320 ft. and a roadway elevation of 147 ft. above the lowest part of the valley which it crosses.

If members of the engineering profession were to carry on their share of a great public work with the extravagance in time and in money which characterize the legal profession in land condemnation proceedings, what cries to Heaven would arise over the incompetence of engineers! An interesting illustration of the way municipal funds are disseminated has just been furnished in New York City, by a board which has had in charge the condemnation of land for what is known as the Grand Boulevard and Concourse in the Borough of the Bronx. This commission, consisting of three men, has been at work almost fourteen years and has made awards amounting to $2,922,000. During that time the commissioners have received as fees $185,933, besides $69,000 in extra allowances. It will be seen that the commissioners have received nearly 10% as much money as their total awards.

The first step toward supervision by the Federal Government of the coal mining industry is the publication by the Geological Survey of the list of permissible explosives which we reprint elsewhere in this issue.

In Great Britain there has been for many years a Royal Commission of Mines a part of whose duty it is to promote measures for diminishing accidents in coal mines. The British Coal Mines Regulation Act was put into effect in 1872 and comprised a complete disciplinary code in all matters connected with coal mining, including the use of explosives. Since that time, the average death rate in British coal mines has been reduced about one-half. Deaths from falls of rock, which outnumber those for any other one cause, however, have not been appreciably diminished in Great Britain during the past 20 years; the reduction effected is mainly in deaths from hoist accidents and explosions.

Disastrous explosions of coal dust in the great majority of cases are set off by the flame of a blast—usually a "blown-out shot" due to improper tamping or shooting from the solid instead of undercutting. Prevention of the accumulation of the finest—and therefore most dangerous—dust in coal mines is practically impossible. The wetting of this dust by water sprays is of doubtful advantage and tends to increase falls of rock. It is claimed that in many mines the liability of dust explosions is enhanced by the velocity of air currents maintained by the ventilating fans, in that, with air currents of higher velocity, more dust is held in suspension; but to reduce the air supply is to subject the miner to unhealthful conditions of poor ventilation and at the same time to increase the danger of gas explosions. The most that can be expected from the use of zones of stone dust such as have been extensively experimented with in England, is the diminishing, to some extent, of the extent and violence of the explosions.

Since it is impracticable to do away with the coal dust and since no satisfactory means of rendering it harmless has been brought forward, the only recourse is an attempt to lessen the chances of its being ignited. The experiments at the Pittsburg testing station indicate that these chances depend in large measure upon the extent and duration of the flame of the blast. The flame of black powder, compared with that of an equal amount of a permissible explosive, is more than three times as far reaching and has from 3,000 to 4,000 times as great duration.

One of the notable papers presented at the annual convention of the Association of State Railway Commissioners in Washington last week referred to the methods of tariff making in vogue in railway traffic departments. The author of the paper, Mr. Martin S. Decker, of the New York Public Utilities Commission, urged that railway tariffs ought to be simplified. He said that, according to the theory of the law, shippers are supposed to read published tariffs understandingly. As a matter of fact, however, shippers rarely read them, seldom understand them, and are generally compelled to rely, often with damaging results, upon the rate quotations supplied by the local freight agents.

Mr. Decker is not the first person, inside or outside of railway circles, to whom the need for a radical simplification of railway rates has occurred. It is freely admitted by railway officers who have had most to do with rate-making, that our present-day rates are based on a labyrinth of makeshift compromises and guesses, and that a large proportion of the present variations in rates have no justification either in the cost of the service or the value of the service rendered.

This is a matter, however, in which reforms ought to come from within rather than without. The railways themselves ought to take up the matter of rate simplification. They can do it far better than any outside commission or committee can do it for them; in fact, it would be impossible, without an intimate knowledge of the factors affecting cost of freight handling, to make any reasonable and fair rate tariff. Simplified rates would do much to improve the relations between the railways and shippers, and would remove a fruitful source of graft and discrimination.

The Panama Canal: A Work Worthy of National Pride.

We print in this issue the Isthmian Canal Commission's annual report. As we do so it is instructive to reflect upon the change in temper of the public, or at least of the public press, toward the Panama Canal during the year since the last annual report appeared.

It is regrettable, but true, that up to some six months ago the matter published in American newspapers regarding the Panama Canal enterprise was chiefly carping criticisms based on misstatements of facts. From the very beginning of the enterprise, those who have been in responsible charge have been a target for fault-finding and abuse, with the result that the public, or at least a large share of it, unquestionably formed the impression that the nation's work at Panama was more or less of a muddle.

It is probably not worth while now to discuss the reasons why American newspapers have been so much more ready to "throw mud" at the Panama enterprise and every one responsible for its conduct than they have been to award credit where credit is due. The fortunate fact, which we take great pleasure in recording, is that the era of mud-throwing appears to have passed.

The reports brought back from Panama by the many who have been to the Isthmus and have studied the work actually in progress, have at last overbalanced the influence of the sensational press in molding public opinion. People have at last come to understand that the Nation is not only constructing the Panama Canal, but that it is doing the work at an extraordinarily rapid rate.

We have faith that this remolding of public opinion will continue until due credit will at length be awarded by the public to the able engineers who are toiling, year in and year out, under the heat of a tropical sun, to carry out for the United States the greatest engineering work the world has ever seen.

The excavation work on the canal has recently passed the half-way mark. The lock pits are practically excavated, and concrete laying is in progress on both the Atlantic and Pacific locks, although not yet at the rate which will be attained when all the machinery contracted for is in place and working at full capacity.

While the public has come to understand that the Panama work is going forward with rapid strides, and while people are at last becoming convinced that the engineers really understand their business so far as the plan of the canal is concerned, there appears to be still a popular belief that the work is being done "regardless of expense."

This is not at all strange in view of the great increase in estimated cost since the Panama route was first adopted seven years ago. At that time $140,000,000, in round numbers, was the estimated construction cost; but the estimate of final cost prepared by the Canal Commission last February shows a total for engineering and construction of $298,000,000, in round numbers. It is far from strange that this great increase in cost is quoted, on the one hand, as proof of the unreliability of engineers' estimates, and on the other hand as proof that the Army engineers now in responsible charge are conducting the work in an extravagant way.

Both these ideas hurt the engineering profession in the eyes of the public. We believe, therefore, that engineers at least should be informed as to why both these ideas are incorrect.

As to the estimate made by the Canal Commission of 1901, then, it is to be noted that that estimate was for a canal very much smaller than the canal which is now being built. It was Congress and not the engineers that ordered a large increase in the dimensions of the canal. This increase in dimensions has compelled an increase of about 50% in the quantities to be handled. At the same time there has been a great advance in the cost of labor and materials since the estimate of 1901 was framed. A man who should build in the United States to-day a house for which plans and estimates were made eight years ago, would probably find the cost increased by fully 20% over the original estimate. A similar increase in cost of labor and materials has occurred on the Panama work; but no discredit should attach to the engineers who framed the estimate of eight years ago because of this increase. Besides this, Congress applied the eight-hour law to the Isthmus, whereas the original estimates were based on a ten-hour day.

Perhaps some one may say that the engineers ought to have foreseen the advancing scale of prices and the probabilities of eight-hour legislation in framing their estimates; but we do not

know of any engineers endowed with such a gift of foreknowledge. If any engineer were fortunate enough to be able to forecast market prices even six months ahead, he would not have to follow the engineering profession for a living.

We might say much more concerning the early estimates of cost on the Panama Canal; but we turn now to the charge that those now conducting the work are not giving due heed to economy. This charge is disproved, in the first place, by the universal testimony of many who have visited the Isthmus, who have been thoroughly competent to judge and who have given careful study to the organization and methods there in force. We could quote many illustrations showing that the engineers at Panama are laboring energetically, not only to secure a high class of construction, but to carry out the work at the least cost to the United States. Limits of space confine us to a single one.

To the reader who has an idea that the canal work is being carried on extravagantly and inefficiently, we commend the figures given below showing the cost of manufacturing repair parts in the Canal Commission's shops at Empire.

It should be explained, in the first place, that to keep in repair the great number of steam shovels, locomotives, cars, etc., which are used in the canal construction, it was necessary to erect large repair shops, quite equal to those that would be installed by a railway company having an equal amount of rolling-stock. The service is extremely severe on all classes of rolling-stock, and it is necessary to keep the cars and locomotives in first-class condition to prevent breakdowns and consequent blockades and interruptions to the work.

These repair shops, necessarily, work under some disadvantages, compared with shops in the United States, particularly shops of manufacturing companies. The cost of labor is extremely high, when all the advantages offered in the way of short hours, vacations, etc., are taken into consideration, and the climate is more or less trying on men engaged in shopwork. It might naturally be supposed that under the conditions above described it would be cheaper to buy repair parts from the manufacturers in the United States than it would be to make them in the shops on the Isthmus.

In order to test this matter, the Commission made up, a year or so ago, a list of a considerable number of repair parts used in connection with the dump cars. It asked bids on these repair parts from five American manufacturers, and also from its own Department of Motive Power and Machinery. The latter department, of course, based its figure on the cost of producing the parts in the Commission's shops. We have in our possession a large table showing these comparative bids, and the recapitulation of this table we have summarized as follows:

Castings.	Bidders. A.	B.	C.	D.	E.	I. C. C.
Class No. 1	$17,358.70	$18,737.75	$21,639.65	$17,370.20	$17,298.18	$16,549.57
Class No. 2	1,396.00	1,457.25	2,327.75	1,547.88	1,396.25	1,370.97
Class No. 3	1,759.70	1,953.50	2,002.40	1,679.87	1,876.40	1,576.21
Class No. 4	4,453.70	4,432.70	4,800.60	4,017.40	4,448.35	4,294.75
	$24,968.10	$26,581.20	$30,770.40	$24,615.55	$25,018.18	$23,791.50

The last column of this table, headed "I. C. C.," is the cost of doing the work in the Isthmian Canal Commission's own shops, based on actual shop cost records. It will be seen that this cost was found to be actually less than the prices bid by the manufacturers for the materials laid down at Colon. Mr. George D. Brooke, the Superintendent of Motive Power and Machinery, guaranteed to the Commission that the prices his department gave were accurate within an error of 2% either way.

A similar comparison was made in connection with the purchase of grate castings. Bids received for grate castings from the United States foundries ran from $1.85 to $3.50 per hundred pounds. The statement submitted by Mr. Brooke in connection with his bid for the work showed that the castings could be turned out of the Commission's shops for from $1.55 to $1.65 per hundred pounds.

It may seem almost incredible that this repair shop, 2,000 miles from the centers of civilization and supplies, located in a tropical climate and relying on expensive and more or less inefficient labor, could beat prices made by responsible and well-managed firms in the United States. Yet the explanation presented by Mr. Brooke makes the matter easily understandable. We quote from his statement as follows:

I do not have to figure on taxes on the plant.

I do not have to figure on the manufacturer's profit. I do not have to figure on the selling agent's profit in addition to the manufacturer's profit, as some of the low bids put in are through selling agents in New York.

There is a disinclination amongst reputable manufacturers in the states to deal with the government without an extra compensation to cover the necessary "red tape" and delays in obtaining payment.

I do not have to deal with the fear that liquidated damages are liable to diminish the profits. The manufacturer is very apt to add to his bidding price to protect a contingency of this kind.

I do not have to figure on the extra cost brought about by the packing, which, with fragile castings, is liable to be quite a percentage of the cost of such low-grade castings as grates.

I do not have to figure on a breakage percentage in shipment, which is liable to be excessive unless there is an extraordinary expense in packing.

Again, the raw material in the shape of pig-iron, bar-iron, etc., when sent to the Isthmus, is a lower grade classified freight than manufactured material and I do not have to figure on the difference of this freight rate.

If we have to buy castings we must keep a six months' to a year's stock on hand and there is properly an additional cost to be added to purchased castings for interest on this large amount of stock. But making castings ourselves on the Isthmus, the stock on hand can be kept at a minimum and emergencies can be met as they arise without bringing about consequential delay costs.

We now have the patterns already made for nearly all types of castings that will be required. The value of these patterns has already been charged out against our casting account. If castings are purchased by contract, each bidder would have to make the pattern covering the type of castings required and we will necessarily have to pay for same and it will enter into the cost of the castings.

Continuing, Mr. Brooke showed, among other things, that it was extremely advantageous for the work to have the castings made at the repair shops, which are closely in touch with the engineers engaged in using the cars and locomotives. As fast as weaknesses develop in a casting, for example, the pattern can be changed to meet it. But if a six months' supply of castings purchased in the United States were on hand, this whole supply would have to be used up before any change could be made.

We call attention to this case simply as an illustration of the businesslike efficiency with which operations on the Isthmus are being carried on. We have closely followed the work at Panama, and we believe the methods above described are typical and not exceptional. It is true that the engineers in charge of the work at Panama are spending enormous amounts of money, but they are making an honest endeavor, and we believe a successful endeavor, to secure for the United States value received for every dollar spent.

We think it worth while to appeal to the engineering profession at this time for a better appreciation of the work that is being done by the members of the profession at Panama. We constantly hear complaint that the public does not appreciate the work of the engineering profession. But why expect the public to appreciate the work of the engineer unless the profession itself appreciates and takes pride in the work that its own members are accomplishing?

European engineers are following with great interest the Panama work, and considerable numbers of them are visiting the Isthmus to study the methods that are being followed there. A far larger number of engineers from the United States would find it well worth while to make the trip to Panama while the work is in full swing. Why should not some one or more of our great national engineering societies take interest enough in the Panama work to organize an excursion to visit it?

LETTERS TO THE EDITOR.

The Term, "The Engineer," in Contracts Should be Defined.

Sir: Will Engineering News please define the term "the engineer" when it occurs in plans for municipal contracts? Does it mean the engineer in charge of the work proper, the chief engineer, or the consulting engineer?

I have before me the plans of what is known as Section No. 1, of the Gold Street sewer, Brooklyn, showing a tube 4,200 ft. long, exclusive of outlet and connecting chamber, and ranging from 12 ft. 6 ins. to 13 ft. 6 ins. in diameter. The cost with appurtenances was about $500,000.

A cave-in occurred in this sewer about a year ago which resulted in the loss of twelve lives. Responsibility for the accident was never placed, therefore the widows and families of the dead men are left without redress of any kind.

The advertised plans, approved and signed by the Consulting Engineer of the Borough, the Chief Engineer of Sewers, and other Borough officials, gave the contractor his choice of five different methods of construction and in each case the volume of materials called for in the work, and therefore its cost, was determined, not by the plans and specifications, but by "the engineer."

The method of construction followed consisted of an ordinary concrete tube, without reinforcement, with brick-lined invert, in open cut from 20 to 45 ft. in depth. Under each hip of the sewer at the bottom of the trench next to the sides, but inside the cross-section that outlined the way the sewer was to be built, the plan shows a vacant three-cornered space marked "If ordered by the engineer, concrete shall be placed here." All such concrete was to be paid for extra and every cu. ft. of this concrete put in, meant additional timbering, and a cu. ft. of excavation to be taken out, and vice versa. Each little lump is 2 ft. 6 ins. on the side and varies from 4 ft. 2 ins. to 4 ft. 6 ins. on the base.

If this extra concrete (missing concrete is the proper term for it) was put in, it meant driving the sheathing on the sides down flush to the bottom, clearing the excavation out level, and laying the pine flooring, upon which the sewer was to rest, across the full width of the trench, and filling out the angles with the so-called extra concrete. With the concrete omitted, all this was avoided and the bottom of the trench just scooped out round to fit underneath the circle of the sewer invert. As that part of the work was always below water level, and the ground therefore soaking and heavy, it will be seen how important it was which method was adopted both from the point of cost and of safety against sliding. If the concrete was put in, it meant $10 extra per lineal foot of the sewer, or $42,000 extra on the whole job.

Thus not alone all this additional money but the strength and cost of the structure, and to an extent, the safety of the workmen, depended not upon specific designs laid down on the plans, but upon the say-so of some one of the three engineers. Which of them was "the engineer"?

Leaving out altogether the question of whether or not this omission in the plans, or call it discretion placed in "the engineer," had anything to do with the accident that cost twelve lives, is not such ambiguity a standing invitation to collusion and fraud in municipal contracts?

Suppose a prospective bidder in such a case inquires in advance about the extra or missing concrete. He may be told that very likely all of it will have to go in, so he bids high on extra concrete aside from the sewer proper. Another inquirer is told that little of the extra concrete will be needed, and so this man bids low on the extra concrete gamble. Whichever wins will naturally exercise diplomacy to avoid the suspended thumb of the engineer, or of the official who controls him, because upon his decision depends the amount of extra concrete, large or small, in either case, and therefore the profitable or unprofitable character of the job. In fact under such circumstances, what is to prevent a selected contractor from having a thorough understanding before bidding?

It may be said that if the situation regarding the sewer in question is as here outlined, the prosecuting authorities would not stand by and see twelve human lives snuffed out without finding out the reason why, but here are the plans and the records to be seen.

I repeat the inquiry: Which of the three engineers is "the engineer"?

Very respectfully,

Michael O'Sullivan.

349 Fifty-fifth St., Brooklyn, N. Y., Nov. 16, 1909.

[In important contracts, it is common to define exactly what official is meant, wherever the

phrase "the engineer" occurs. The practise is one that ought always to be followed, in drafting specifications and contracts, wherever there is any chance for a dispute as to who "the engineer" is.—Ed.]

Is the Saving by Metering Water Offset by the Increased Cost of Plumbing Repairs?

Sir: Referring to the article "Results of Meter Installation in the Water System of Cleveland" in your issue of Nov. 4, I offer this suggestion:

To reach a just conclusion as to the financial effects of the use of meters, an allowance should be made for the increased expense to consumers for plumbing repairs. The decrease in consumption shown was brought about largely, of course, by greater care of leaking fixtures in metered buildings. From 1902 to 1908, within the buildings, averaging 48,000 in number, having meters, it seems not improbable that there was paid out for plumbers' work, in excess of what would be spent in a like number of unmetered buildings, more than the $80,876 per annum apparently saved.

Yours truly,

S. D. Dodge.

Cornwall-on-Hudson, N. Y., November 9, 1909.

[Is there really an increased expense for plumbing repairs? It costs no more to put a new washer on a leaking faucet or water closet tank to-day than it will a week or a month hence. Householders generally repair leaky plumbing eventually, even though they pay for water at a fixture rate without regard to the amount used or wasted. When water is paid for by meter, however, the householder is apt to have the leak repaired promptly and not neglect it for weeks or months. Apart from leaks in fixtures, the sale of water by meter discourages wasteful habits in the use of water, leaving faucets open, for example, or lawn hose running all night long.—Ed.]

Advertising for Bids for Professional Services.

Sir: We have long realized the fallacy of municipalities advertising for bids for professional services, believing that professional work is not a commodity to be sold at the cheapest price, and that such competition usually results in the city securing as cheap an engineer as he, himself, sets upon his services. To illustrate the extremes to which officials will go in this matter, we enclose a copy of an advertisement, taken recently from a paper in a city of 10,000 people, for the services of a physician, no references or experience being asked for. It is presumed that competition is open to veterinary surgeons, quack doctors, druggists, or any one with sufficient ability to write out a prescription. The advertisement states that the contract will be awarded to the lowest responsible bidder.

Burns & McDonnell,

Civil, Hydraulic and Sanitary Engineers.

Scarritt Building, Kansas City, Mo., Nov. 12, 1909.

[The important portions of this proposal are as follows:

Notice is hereby given that the Board of County Commissioners of . . . County . . . will, at its December session, 1909, receive and invite sealed proposals from resident practicing physicians of said county, to furnish medicines and medical attendance and treatment to the poor, sick and infirm of said county and to the inmates of the county jail, for the term beginning . . . Such services shall also include surgical treatment of such poor, sick and infirm and inmates of the county jail.

The person to whom shall be awarded the contract for the service of county physician, as above advertised for, will be appointed to the position of County Health Officer, at a salary of $75.00 per month, in addition to such salary as he may receive for the service as county physician. . . .

This particular form of proposal is common enough in certain localities in this country, we believe, though it can hardly be commended. The phrase "practising physicians" is a saving grace provided the county officials choose so to regard it, for in most states the law requires ample examinations before a physician can be registered and the medical societies see to it that only reputable men are allowed to practice. So if the officials are honest in their intentions, there would seem to be no danger of a quack doctor getting the position, as feared by our correspondents. However, as the quality and amount of service to be rendered by a professional man is impossible to gage exactly, the policy of advertising for low bids for that service certainly puts a premium on poor work.—Ed.]

Care in the Construction of Vitrified Brick Streets.

By WILL P. BLAIR.*

The demand for improved streets and highways was never more insistent than it is to-day. Never has there been so much public expenditure to meet that demand as at the present time. But the study of details in such street construction which is required to obtain the best results, is not commensurate with the amount of money expended.

Engineering and architectural works costing less money, such as bridges, dams, and structures which should no more receive attention and supervision in construction than is given to the average street pavement would be utterly worthless. The details of pavement construction which are necessary if the material is to be used to the best advantage seem to be often ignored altogether. Sometimes these details are lost sight of in the effort to obtain material of high quality. It is not, however, the purpose of this article in any degree to lessen efforts for a high quality of paving material, but only to induce greater attention to construction details.

Many details noticed in this article are applicable in the construction of granite rock pavements, and if attended to would eliminate many of the objections to such pavements.

*Secretary of National Paving Brick Manufacturers' Association, Board of Trade Bldg., Indianapolis, Ind.

Preparation of the subgrade for a vitrified brick street pavement should have the same care as would be given to a street before paving with any other material. The subgrade should be drained, graded and compacted. Each step should be intelligently supervised and inspected, otherwise the tile for drainage may not drain, and the grade may not conform perfectly to that of the finished street. Perhaps the greatest waste of energy in this stage of the work is in the use of a roller altogether too heavy for its purpose, and in the endeavor to compact layers of earth too thick to make compacting possible.

The curbing should be put in preceding the final preparation of the subgrade.

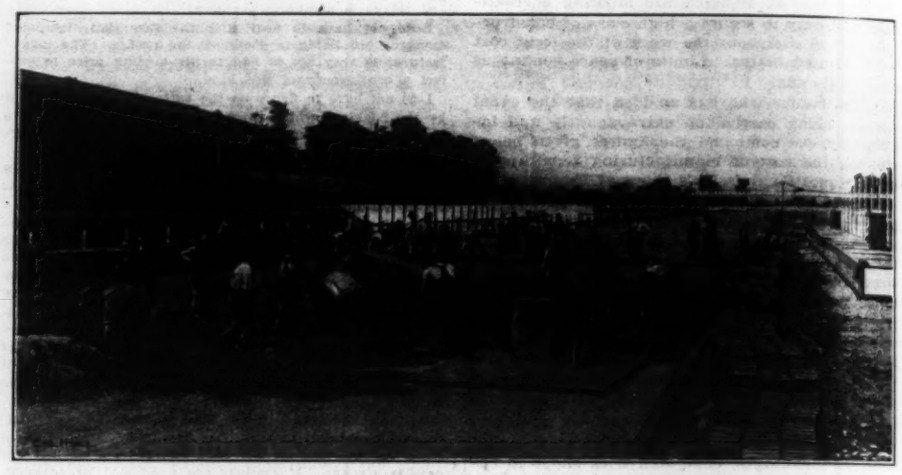

FIG. 1. SPREADING THE 2-IN. SAND CUSHION TO CONFORM TO THE TRUE CURVATURE OF THE STREET CROSS-SECTION.
(Showing in the background the dropping of brick face edge up.)

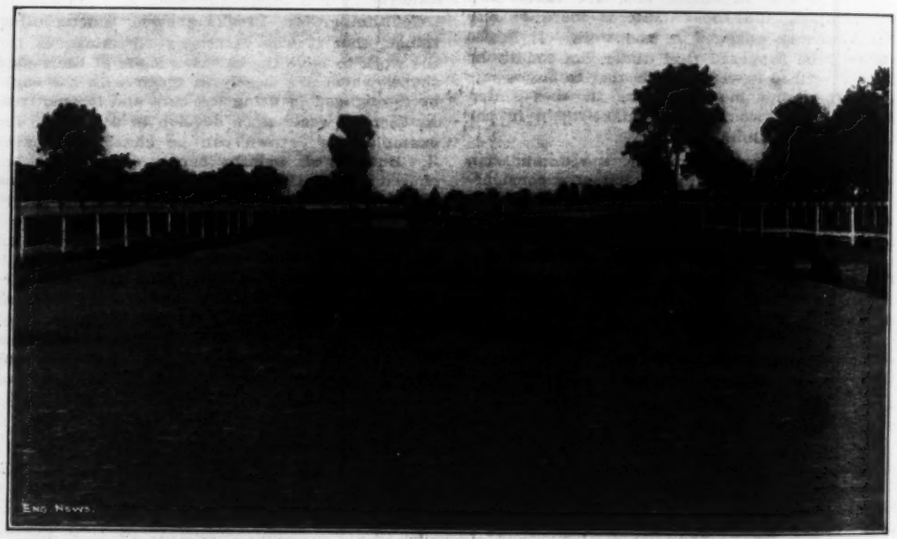

FIG. 2. PAVEMENT INSPECTED, SWEPT, ROLLED AND REINSPECTED, READY FOR THE CEMENT FILLER.
THE LAYING OF VITRIFIED BRICK PAVING ON THE INDIANAPOLIS MOTOR SPEEDWAY.

The foundation should be of concrete made up with never less than 1 part of Portland cement to 8 parts of gravel or broken stone and sand. The foundation must be made smooth and must conform to the grade of the finished street. This one thing which is absolutely necessary is often overlooked, neglected and not infrequently declared impracticable and even impossible by both contractors and engineers; yet it is easy of accomplishment. The chief points to look after are the proper consistency of the concrete mixture and its proper smoothing. The latter may be conveniently done with the back of a dirt shovel in the hands of a skilful man, guided, of course, by grade stakes set 5 ft. apart each way, or a screed reaching across the width of the street.

Upon the foundation thus prepared, there

should be spread a cushion of sand, which should be clean and free from foreign or loamy matter, although it need not necessarily be sharp. The sand should be spread by the aid of a template, reaching the whole or part way across the width of the street, and made to conform to the desired curvature of the street cross-section. A hand roller should be used to insure a uniform compression of the entire sand cushion. The sand should be 2 ins. thick before the compression of the brick by rolling.

The purpose of this sand cushion is to afford some relief from the vibration made by the impact of traffic upon the pavement, and yet this provision for relief must be so slight that no weight likely to come upon the pavement will crush the bond of the cement filler with which the interstices between the bricks are to be filled.

The delivery of the brick along the route of work should precede all other preparation for the work. The brick should be distributed on either side of the street and carefully protected from soiling by *mud* and *dirt*.

An expansion cushion should be provided next to the street curb. It should be 1 in. or more in thickness, according to the width of the street. This cushion should be composed of pitch or asphaltum composition filling two-thirds the allotted space, the upper third to be filled with sand. The board to occupy the space should be a beveled one and 8 ins. in width; it should be placed before the brick are laid next to the curb and left there until after the application of the cement filler; but it should be withdrawn from its place within 36 hours after the application of the cement filler. No transverse cushion is advisable.

After the sand cushion and expansion board are ready, the bricks should be dropped in place with their *best* edge up, in courses at right angles to the street. While it may not add to the utility, the beauty of the street is greatly enhanced if the joints are broken uniformly by halves. The best practice is to have the brick carried from the piles on a board and deposited with the best edge in a position suiting the movement of the hand of the brick paver, so that the best edge will be up, and the workman placing the brick will not have to look for the best edge before dropping the brick into place. This is also the most economical practice for the contractor as the paver can work faster and fewer brick have to be turned after placing. However, any brick which are found to be in place with the wrong edge up should be turned and such as do not meet the requirement of quality should be removed.

FIG. 3. APPLICATION OF THE CEMENT FILLER.
(Showing the sprinkling of brick, the proper mixing boxes, and lifting mixture to the street with the scoop while it is being stirred.)

FIG. 4. THE PROPER APPLICATION OF THE SECOND COAT.
(The combined use of rubber scrapers and brooms in filling every joint flush with the top of the brick.)

THE LAYING OF VITRIFIED BRICK PAVING ON THE INDIANAPOLIS MOTOR SPEEDWAY.

Brick having mud upon them should not be allowed in the street, and all trash and dust should be swept off the brick before the rolling begins. The object of repeated rolling is to iron out slight depressions, compact the brick into the sand cushion, as well as compact the sand cushion underneath, thereby insuring the perfect cushion effect for relief from vibrations before mentioned. It is therefore important to allow no departure from the following rule:

Using a steam roller not exceeding 5 tons in weight, commence near the curb at a very slow pace and continue back and forth until the center of the pavement is reached; then pass to the opposite curb and repeat in the same manner to the center of the street. After the first passage of the roller, the pace may be quickened and the rolling continued until each brick is firmly imbedded in the sand cushion. The roller should then be started at the end of the block and the pavement rolled transversely at an angle of 45° to curb. Then repeat the rolling in like manner in the opposite direction. Before this transverse rolling takes place, all broken or injured brick must be taken out and replaced with perfect ones.

Any departure from the foregoing rule always brings disaster. The use of too heavy a roller or of a horse roller careens the brick and an uneven distribution of sand follows. If commencement is not made at the gutter, the end interstices are widened out of proportion in the crown. It is only possible to iron out the remaining small depression in the pavement by the 45° transverse rolling. The brick should again be inspected and any defective brick disclosed by the action of the roller removed. In replacing, care should be taken to insure perfect compacting by the use of a hand rammer.

Not only should the brick be thoroughly inspected at this stage, but the work as a whole should not be allowed to proceed further unless it meets every requirement, as discrepancies can now be discovered and corrections can be made, which it will be too late to correct when the street is complete. Defects caused by failure to comply with specifications, when not corrected at this time, will surely develop, though it may be five years hence.

May we not emphasize just here that the practice of inspection by officials after the work has been finished, or even after it has progressed to a point where defects may be hidden, is unjust to the contractor, an outrage upon the public and inexcusable from every standpoint. By such practice the supervising authority becomes particeps criminis in defrauding the public. The work should be inspected while it is in progress.

Perhaps the worst, as well as the most varied practices in brick street construction obtain in the application of the cement filler. A little thought as to what is desired might easily show the folly of many methods employed. What is desired is to put in place in the interstices between the bricks a mixture of sand and cement of a quality to insure the greatest strength.

This cannot be accomplished except by a strict compliance with well defined rules, easy to follow, but none the less important. The street must first receive a gentle sprinkling of clean water, thoroughly dampening the entire surface, sides and ends of the brick. The sand for the filler mixture should be dry. No greater quantity than one-third bushel of sand and a like amount of cement should be used in *one batch*. The mixture should be stirred to an even consistency. Water should be added forming a liquid mixture of the consistency of thin cream. This mixture must be kept in constant agitation until it is in place.

The proper box for mixing and applying the filler is a pre-requisite. It should be 3½ to 4 ft. long, 12 to 14 ins. deep, and its ends should set at an angle of 45° with the bottom, standing on uneven legs, the top of the lowest corner about 18 ins. and the highest corner 28 ins. from the pavement.

The mixture should be lifted quickly with a scoop and deposited so near the box that not even a step should be necessary by the operator. Fourteen men is a proper size gang for three or four boxes in filling a street. In this important work, the correct position of the men is not only im-

portant in the matter of quality of work, but is a matter of economy as well. The men stirring the dry mixture, and those whose duty it is to keep the liquid agitated should stand at the higher end of the box. The men handling the scoop should stand at the lower side—not at the end, if they would deposit the mixture in proper proportion in place.

The work of filling should thus be carried forward in line until an advance of fifteen to twenty yards has been made. Then the force should turn back and cover the same space in the same way, except to make the proportion of the grout two-thirds Portland cement and one-third sand.

To avoid the possibility of clogging at any point there should be a man with a sprinkling can, the head perforated with small holes, sprinkling gently the surface ahead of the sweepers.

Half to three-quarters of an hour after this last coat has been applied, the grout between the joints has fully subsided and the initial set is taking place, the whole surface must be slightly sprinkled and all surplus mixture left on the tops of the brick swept into the joints, bringing them up flush with the surface.

After the joints are thus filled flush with the tops of the brick and sufficient time for hardening has taken place, so that the coating of sand will not absorb any moisture from the cement mixture, ¼-in. of sand should be spread over the whole surface, and in case the work is subjected to a hot summer sun, an occasional sprinkling, sufficient to dampen the sand, should be given for two or three days. The pavement thus finished must remain absolutely free from disturbance or traffic of any kind for a period of ten days at least, in order that the filler between the bricks may become hard and strong.

A RIVAL TO THE PANAMA CANAL SQUELCHED.—The United States should heave a deep sigh of relief this morning when it learns that Luis Arturo Undurraga, the Chilean engineer, has definitely abandoned his effort to obtain from the Colombian Government a concession for his canal project that was to rival Panama. The possibility of Mr. Undurraga opening a competing waterway a few miles away after we had spent somewhere near half a billion making the dirt fly on the isthmus is too fearful to contemplate.

The trouble with Mr. Undurraga was that he wasted his talents on too small a job. A man with his imagination ought to promote a really big enterprise such as pulling off the Jeffries-Johnson fight or establishing an air-ship route to Mars.—"Pittsburg Dispatch."

Tables for the Determination of Earth Pressures on Retaining Walls.*

By C. K. MOHLER.†

Perhaps no other subject, with which the engineering profession is concerned, has so little available data of a reliable character for practical application, as that relating to earth pressure. The plea has been made repeatedly for an extended series of tests to determine by actual experiment the amount of pressure produced by retained earth against the retaining surface under the many varying conditions, covering the different angles of repose, surcharge, back of wall batter, etc. The late Benjamin Baker in his treatise on "The Actual Lateral Pressure of Earthwork," says:

> Long as the subject has occupied the attention of constructors, there is probably none other regarding which there exists the same lack of exact experimental data, and the same apparent indifference as to supplying this want.

Up to the present time no extended experiments on a large scale have been made to the knowledge of the writer. Results obtained from small model tests are practically valueless. The available formulas for computing earth pressure are based almost wholly on theory and small model tests. Some of these formulas are so long and complicated that for practical purposes they are but little used. To work out results from them is, to say the least, a burdensome task. For that and other reasons walls for important work are often designed without computations having been made to determine the probable earth pressure.

In order to get some of the available data on earth pressure in the most convenient shape for use and comparison the accompanying tables were computed from theoretical formulas. They cover a considerable range for the varying conditions governed by natural slope, surcharge, and back of wall batter. The tables were computed: (1) From the analytical theory of Rankine, as developed by Prof. M. A. Howe, in "Retaining Walls for Earth." (2) The theory of the sliding prism, of Vauban and graphics of Rebhann, as given in "Earth Slopes, Retaining Walls and Dams," by Prof. Charles Prelini.

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The conventional abbreviations used are:

ϕ = The natural slope or angle of repose.
ϵ = angle of surcharge of fill back of wall.
α = angle of back of wall batter with vertical.
ϕ' = the angle of friction between the earth and the back of the wall.
δ = angle which the direction of the resultant earth pressure makes with the horizontal.
h = height in feet of fill retained.
γ = weight of fill or backing in pounds per cu. ft.
C = constant based on unity from which the earth pressure E is obtained for different heights of wall or fill h.
E = earth pressure, in pounds, for 1-ft. length of wall = the constant C into the square of the height $h = C h^2$.

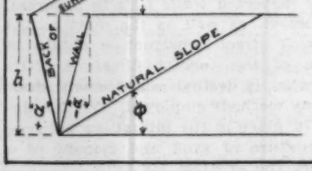
In column (1) (Figs. 1 and 2) the following slopes and angles of repose are given: 1 to 1 ($\phi = 45°$), 1¼ to 1 ($\phi = 38° 40'$), 1½ to 1 ($\phi = 33° 42'$), 1¾ to 1 ($\phi = 29° 45'$), 2 to 1 ($\phi = 26° 34'$), 2½ to 1 ($\phi = 21° 48'$), 3 to 1 ($\phi = 18° 26'$), 4 to 1 ($\phi = 14° 02'$), 6 to 1 ($\phi = 9° 28'$), and level ($\phi = 0$) or hydrostatic pressure.

The angles of surcharge are given in column (2). The values for back of wall batter, varying by one inch in twelve increments, are given at the top of the table, ranging from vertical ($\alpha = 0$) up to 6 ins. in 12 ins. ($\alpha = 26° 34'$). Also 8 ins. in 12 ins. ($\alpha = 33° 42'$), and a few values for 12 ins. in 12 ins. ($\alpha = 45°$). Negative values of α are given (back of wall batter sloping up toward the fill) by 1-in. increments up to 5 ins. in 12 ins. ($\alpha = 22° 37'$).

In columns under the heading of C are given the constants obtained for different angles of repose, surcharge, back of wall batter, etc. In columns headed δ are given the angle which the resultant earth pressure E makes with the horizontal for such cases as formulas were given for obtaining the results. In the table for the "sliding prism theory," Fig. 2, the values of δ are not given as they are readily found by adding the angle of repose ($\phi = \phi'$) to the back of wall batter α for any given case. To illustrate: If ($\phi' = \phi = 33° 42'$) and $\alpha = 14° 02'$ the angle of resultant $\delta = 33° 42' + 14° 02' = 47° 44'$. When α is negative $\delta = \phi' - \alpha$. Whence for $\phi' = 33° 42'$, $\alpha = -14° 02'$, $\delta = 33° 42' - 14° 02' = 19° 40'$.

EARTH PRESSURE CONSTANTS (C) AND ANGLE (δ) OF RESULTANT WITH THE HORIZONTAL FOR DIFFERENT ANGLES OF REPOSE φ, INCLINATIONS OF SURFACE ε, AND BACK OF WALL BATTER α. ANALYTICAL THEORY. RANKIN'S METHOD. AFTER HOWE.

EARTH SLOPES AND ANGLES OF REPOSE φ	SURFACE SLOPE BACK OF WALL ε	BATTER AND ANGLE OF INCLINATION α OF BACK OF WALL TO THE VERTICAL. VERTICAL 0° 00	1" IN 12" (1 IN 12) 4° 46	2" IN 12" (1 IN 6) 9° 28	3" IN 12" (1 IN 4) 14° 02	4" IN 12" (1 IN 3) 18° 26	5" IN 12" (1 IN 2½) 22° 37	6" IN 12" (1 IN 2) 26° 34	8" IN 12" (1 IN 1.5) 33° 42	12" IN 12" (1 IN 1) 45° 00	1" IN 12" (1 IN 12) -4° 46	2" IN 12" (1 IN 6) -9° 28	3" IN 12" (1 IN 4) -14° 02	4" IN 12" (1 IN 3) -18° 26	5" IN 12" (1 IN 2½) -22° 37	SURFACE SLOPE BACK OF WALL ε	EARTH SLOPES AND ANGLES OF REPOSE φ
		VALUES OF EARTH PRESSURE CONSTANT C AND ANGLE OF RESULTANT WITH THE HORIZONTAL δ.															
		C δ	C δ	C δ	C δ	C δ	C δ	C δ	C δ	C δ	C δ	C δ	C δ	C δ	C δ		
1 TO 1	0° 00	.06 0° 00	.35 25° 58	.120 44° 11	.182 55° 33	.187 62° 06	.228 67° 37	.266 71° 08	.344 76° 43	.587 79° 17	.25 25° 58	.120 44° 11	.182 55° 33	.187 62° 06	.228 67° 37	0° 00	1 TO 1
	29° 45	.116 29° 45	.153 44° 08	.220 53° 26	.264 60° 15	.314 65° 55	.328 66° 06	.448 68° 16	.601 71° 26		.84 7° 45	.127 18° 47	.208 28° 45	.232 35° 27	.230 41° 08	29° 45	
45° 00	45° 00	.354 45° 00	.488 48° 06	.584 53° 00	.672 56° 20	.801 61° 18	.941 67° 08	1.023 69° 08	1.141 64° 47		.271 38° 17	.328 31° 24	.448 18° 43	.111 4° 06	.93 -2° 11	45° 00	45° 00
1¼ TO 1	0° 00	.116 0° 00	.123 19° 51	.142 36° 58	.170 47° 16	.203 56° 17	.238 61° 06	.276 65° 13	.363 70° 54		.123 -10° 51	.142 -3° 58	.170 4° 16	.203 14° 17	.238 23° 06	0° 00	1¼ TO 1
	29° 45	.170 29° 45	.218 46° 03	.269 47° 22	.329 52° 40	.381 56° 38	.449 59° 18	.522 62° 04	.683 65° 36		.139 15° 26	.181 8° 47	.247 1° 26	.284 -5° 36	.284 -11° 21	29° 45	
38° 40	38° 40	.330 38° 40	.470 49° 50	.565 48° 18	.668 48° 47	.776 50° 26	.898 52° 38	1.023 54° 11	1.305 56° 33		.317 35° 18	.424 28° 21	.523 18° 22	.568 8° 08	.539 -1° 21	38° 40	38° 40
1½ TO 1	0° 00	.143 0° 00	.148 16° 18	.164 30° 13	.190 41° 07	.220 48° 20	.262 55° 36	.288 60° 18	.363 66° 46		.149 -16° 18	.164 -3° 13	.190 11° 07	.220 20° 40	.262 28° 24	0° 00	1½ TO 1
	29° 45	.241 29° 45	.309 37° 18	.348 45° 01	.405 47° 36	.473 51° 09	.546 54° 08	.624 56° 21	.786 60° 42		.283 18° 44	.173 7° 26	.168 -1° 12	.148 -8° 29	.181 -16° 24	29° 48	
33° 42	33° 42	.416 33° 42	.469 37° 59	.570 41° 28	.668 44° 17	.764 46° 41	.866 48° 41	.966 50° 18	1.204 53° 08		.361 28° 08	.334 18° 32	.347 10° 23	.318 2° 44	.283 -5° 27	33° 42	33° 42
1¾ TO 1	0° 00	.168 0° 00	.176 13° 54	.198 26° 20	.218 36° 32	.237 44° 42	.260 51° 02	.301 56° 08	.378 63° 12							0° 00	1¾ TO 1
29° 45	29° 45	.436 29° 45	.508 34° 06	.572 37° 43	.668 44° 26	.734 45° 18	.824 48° 21	.921 47° 24	1.130 50° 26		.328 24° 26	.326 18° 27	.328 14° 08	.347 11° 27	.321 -8° 46	29° 45	29° 45
2 TO 1	0° 00	.191 0° 00	.196 12° 18	.218 25° 36	.228 33° 12	.264 41° 07	.283 47° 26	.316 52° 38	.384 58° 12							0° 00	2 TO 1
26° 34	26° 34	.447 26° 34	.506 30° 58	.571 34° 48	.641 37° 52	.717 40° 36	.788 42° 37	.866 45° 00	.1021 46° 22		.304 21° 28	.348 15° 18	.388 8° 06	.428 0° 00	.456 -8° 58	26° 34	26° 34
2½ TO 1	0° 00	.225 0° 00	.223 10° 18	.244 18° 29	.261 26° 36	.283 36° 01	.318 42° 16	.339 47° 29	.406 55° 31		.233 -18° 10	.246 -18° 58	.261 -20° 36	.283 -16° 01	.318 -12° 16	0 00	2½ TO 1
21° 48	21° 48	.464 21° 48	.513 26° 16	.566 30° 01	.626 33° 26	.688 36° 32	.767 38° 09	.884 41° 27	.906 44° 18		.428 16° 02	.388 10° 54	.364 4° 22	.324 -2° 38	.304 -10° 16	21° 48	21° 48
3 TO 1	0° 00	.268 0° 00	.263 9° 27	.273 17° 27	.288 25° 21	.309 32° 41	.333 38° 44	.364 43° 54	.423 52° 24							0° 00	3 TO 1
18° 26	18° 26	.474 18° 26	.516 22° 57	.563 26° 58	.618 30° 26	.668 33° 41	.724 36° 29	.788 38° 49	.932 42° 13		.437 13° 23	.406 7° 49	.378 1° 46	.352 -4° 46	.341 -11° 33	18° 26	18° 26
4 TO 1	0° 00	.385 0° 00	.368 7° 46	.376 15° 28	.389 22° 18	.347 28° 41	.369 34° 01	.394 38° 22	.452 47° 24							0° 00	4 TO 1
14° 02	14° 02	.486 14° 02	.518 18° 37						.844 46° 46							14° 02	14° 02
6 TO 1	0° 00	.383 0° 00	.361 6° 36	.368 13° 06	.380 19° 12	.396 24° 56	.416 29° 34	.437 34° 12	.480 42° 56		.361 -6° 36	.366 -13° 06	.382 -19° 12	.396 -24° 56	.416 -29° 34	0° 00	6 TO 1
9° 28	9° 28	.493 9° 28	.516 14° 01				.660 25° 33	.681 30° 56	.749 38° 26	.910 44° 16	.476 4° 56				.429 -16° 21	9° 28	9° 28
LEVEL HYDROSTATIC	0° 00	.500 0° 00	.503 4° 46	.507 9° 28	.518 14° 02	.527 18° 26	.548 22° 37	.559 26° 34	.641 33° 42	.767 45° 00	.503 -4° 46	.507 -9° 28	.518 -14° 02	.527 -18° 26	.548 -22° 37	0° 00	LEVEL HYDROSTATIC



ASSUMED WEIGHT OF FILL OR BACKING γ = 100 LBS. PER CUBIC FOOT. h = HEIGHT OF WALL IN FEET.
TO OBTAIN THE EARTH PRESSURE E MULTIPLY THE CONSTANT C BY THE SQUARE OF THE HEIGHT h. E = Ch².

NOTE:-
THE VALUES FOR HYDROSTATIC PRESSURE SHOULD BE CORRECT IN EACH CASE.
WITH α NEGATIVE FEW IF ANY OF THE RESULTS ARE RELIABLE OR CONSISTENT WHEN φ IS GREATER THAN ZERO. (PORTION TO RIGHT OF HEAVY LINE)
WITH α POSITIVE AND ε EQUAL ZERO THE VALUES OF C ARE PROBABLY TOO SMALL, WHILE WITH ε = φ THE VALUES FOR C AND ALSO δ ARE TOO LARGE TO BE THOROUGHLY CONSISTENT.

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FIG. 1. TABLE GIVING CONSTANTS TO BE USED IN DETERMINING EARTH PRESSURE ON RETAINING WALLS.
(Rankine's Method After Howe.)

It is believed that the ranges of natural slope ϕ, angles of surcharge ϵ, and back of wall batter angles α, are sufficiently large to cover most cases met with in practice. Intermediate values of C and δ can be obtained by interpolation near enough for practical purposes.

The constant C was calculated with the assumed value of ν at 100 lbs. per cu. ft., so that for values of ν greater or less than 100 lbs., the value of C to correspond to those values of ν could be readily obtained by multiplying the table value of C by the per cent which the determined value of ν is of 100.

For instance, if C is required for $\nu = 80$ lbs. per cu. ft. multiply the constant C obtained from the table by 0.8. If $\nu = 120$ lbs. multiply the table value of C by 1.2. Let ν' and C' represent the new values; then

$$C' = C \frac{\nu'}{100}.$$

Total earth pressure

$$E = C \frac{\nu'}{100} h^2.$$

Rankine's method are inconsistent and unreliable aside from those given for hydrostatic pressure. The results from Rebhann under the above conditions are more consistent. When the angle of surcharge ϵ is greater than the angle of repose ϕ ($\epsilon > \phi$), both Rebhann and Rankine give results that are not consistent.

The computation and construction of the tables have involved a great amount of time and labor. The results from Rankine's formulas were computed by logarithms and checked by graphics. The results from Rebhann were obtained by graphics. Where direct computations were made the results were checked with a Fuller slide rule. It is believed the results are reasonably correct. In case errors are discovered the author would deem it a favor to have his attention called to any which may be found. The author does not take any responsibility for the errors of theory and has endeavored only to give the results called for by published methods or formulas.

While it is regrettable that we do not have more exact data to use, it is certainly worth considerable to have such as is available in convenient shape, for use and comparison, in tabulated form; not unlike the trigonometric functions and logarithms, whose value for getting results lies almost wholly in the fact of their having been tabulated.

Additional matter is in course of preparation dealing with points not satisfactorily covered by present published theory.

EARTH PRESSURE CONSTANTS (C) AND ANGLES OF RESULTANT (δ) WITH HORIZONTAL; FOR DIFFERENT ANGLES OF SLOPE (Φ), INCLINATIONS OF SURFACE (ε), AND BACK OF WALL BATTERS (α). SLIDING PRISM THEORY. COULOMB AND REBHANN. FROM PRELINI.

BATTERS AND ANGLES OF INCLINATION OF BACK OF WALL WITH THE VERTICAL, α.

EARTH SLOPES AND ANGLES OF REPOSE (Φ)	SURFACE SLOPE BACK OF WALL (ε)	VERTICAL 0° 00		1 IN 12 (1 IN 12) 4° 46		2 IN 12 (1 IN 6) 9° 28		3 IN 12 (1 IN 4) 14° 02		4 IN 12 (1 IN 3) 18° 26		5 IN 12 (1 IN 2.4) 22° 37		6 IN 12 (1 IN 2) 26° 34		8 IN 12 (1 IN 1.5) 33° 42		1 IN 12 (1 IN 12) −4° 46		2 IN 12 (1 IN 6) −9° 28		3 IN 12 (1 IN 4) −14° 02		4 IN 12 (1 IN 3) −18° 26		5 IN 12 (1 IN 2.4) −22° 37		12 IN 12 (1 IN 1) 45° 00		SURFACE SLOPE BACK OF WALL (ε)	EARTH SLOPES AND ANGLES OF REPOSE (Φ)
		VALUES OF EARTH PRESSURE CONSTANTS (C) AND ANGLES OF RESULTANT WITH THE HORIZONTAL (δ).																													
		C	δ	C	δ	C	δ	C	δ	C	δ	C	δ	C	δ	C	δ	C	δ	C	δ	C	δ	C	δ	C	δ	C	δ	C	δ		
1 TO 1	0° 00	87		106		117		133		153		173		197		243		73		61		56		38		31		354		0° 00	1 TO 1
	29° 45	147		176		209		251		298		338		399		514		124		99		79		64		47				29° 45	
45° 00	45° 00	261		298		346		406		468		543		638		837		207		172		143		113		89				45° 00	45° 00
1½ TO 1	0° 00	116		131		148		166		187		206		231		284		180		86		74		63		50				0° 00	1½ TO 1
	29° 45	285		322		373		428		473		531		604		758		262		233		205		178		154				29° 45	
38° 40	38° 40	386		345		395		446		511		583		661		848		261		225		196		170		143				38° 40	38° 40
1½ TO 1	0° 00	142		159		177		198		216		238		266		326		128		113		102		89		78				0° 00	1½ TO 1
	29° 45	286		332		379		426		473		531		600		758		262		232		205		178		154				29° 45	
33° 42	33° 42	345		384		429		484		544		612		687		866		303		269		242		215		189				33° 42	
	45° 00	650		694		755		815		892		983		1096		1356		627		611		622		642		783				45° 00	33° 42
1¾ TO 1	0° 00	169		186		206		226		246		267		292		349		155		142		128		116		104				0° 00	1¾ TO 1
	29° 45	322		413		457		505		561		626		694		867		339		309		281		256		232				29° 45	
29° 45	45° 00																													45° 00	29° 45
2 TO 1	0° 00	181		211		228		245		262		281		303		363		177		162		151		137		123				0° 00	2 TO 1
	26° 34	393		438		468		514		567		624		692		849		360		331		308		285		263				26° 34	
26° 34	45° 00																													45° 00	26° 34
2½ TO 1	0° 00	229		246		264		281		301		326		347		401		211		293		182		176		166				0° 00	2½ TO 1
	21° 48	429		465		496		536		584		631		689		829		402		378		357		339		322				21° 48	
21° 48	45° 00																													45° 00	21° 48
3 TO 1	0° 00	259		278		291		310		329		351		375		422		246		231		222		210		198				0° 00	3 TO 1
	18° 26	449		476		500		546		587		636		689		813		423		404		389		373		361		1133		18° 26	
18° 26	45° 00																													45° 00	18° 26
4 TO 1	0° 00	306		319		338		353		368		388		410		459		294		283		272		263		256				0° 00	4 TO 1
	14° 02	420		489		513		542		574		614		657		766		446		431		419		411		406				14° 02	
	29° 45																													29° 45	
14° 02	45° 00																													45° 00	14° 02
6 TO 1	0° 00	369		370		383		399		416		430		461		505		349		343		339		336		331		617		0° 00	6 TO 1
	9° 28	484		501		516		541		560		588		630		723		421		461		456		452		451		937		9° 28	
9° 28	9° 28	1082		1082		1086		1090		1095		1100		1110		1130		1085		1088						1147		2764		46° 00	9° 28
LEVEL (HYDROSTATIC)	0° 00	580	0° 00	582	4° 46	587	9° 28	595	14° 02	627	18° 26	648	22° 37	678	26° 34	691	33° 42	582	−4° 46	587	−9° 28	595	−14° 02	627	−18° 26	642	−22° 37	707	45° 00	0° 00	LEVEL (HYDROSTATIC)

ASSUMED WEIGHT OF FILL OR BACKING γ = 100 LBS. PER CU. FT.

TO OBTAIN THE EARTH PRESSURE E MULTIPLY THE CONSTANT C BY THE SQUARE OF THE HEIGHT h IN FEET. $E = Ch^2$ = EARTH PRESSURE IN POUNDS.

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Determined by graphics (with angle for directrix equal ϕ). δ is found by adding α to ϕ for any case (subtract α when negative).

FIG. 2. TABLE GIVING CONSTANTS TO BE USED IN DETERMINING EARTH PRESSURE ON RETAINING WALLS. (Sliding Prism Theory.)

By means of the data made available in usable shape, results can be obtained conveniently and quickly for comparison and use under a great range of different conditions, covered by the several theories. It goes without saying, that for any given height of wall and backing, the constant C, as given in the tables, will indicate the *relative* values of the earth pressure E resulting from the different values of ϕ, ϵ and α without multiplying out by h^2 to find the actual value of E.

For back of wall vertical and top of fill level with top of wall the values for C given by the different theories are almost identical. For different values of surcharge ϵ, and back of wall batters α, the variations for the value of C become considerable when the angle of repose ϕ remains the same. As an instance, with $\phi = 45$, surcharge angle $\epsilon = 45°$, and back of wall batter angle $\alpha = 33° 42'$, Rankine gives $C = 144.1$, while Rebhann gives $C = 83.7$. The result given by Rankine is 72% in excess of that given by Rebhann. Many other variations will be noted.

For negative values of α the results given by

A NEW METHOD OF BONDING NEW CONCRETE to old is described by Mr. Frank Barber (of the firm of Barber & Young, Toronto, Ont.) in a recent article in "The Canadian Engineer." This consists in placing bags of cracked ice on the last surfaces of concrete placed at night, thus reducing the temperature of the concrete, and consequently retarding its time of setting, so that on the next morning the surface is still plastic and the concrete then placed will set in one mass with the old. The invention of this scheme is credited to Mr. O. L. Hicks, when he was contractor for a reinforced-concrete truss bridge in Ontario. As all of the members in these trusses were of relatively small cross-section, the ice-bags were easily placed at the end of a day's work and it is stated that the method worked very successfully. To what extent it could be applied to heavier work is not as yet known.

Annual Meeting of the Society of Naval Architects and Marine Engineers.

The 17th annual meeting of the Society of Naval Architects and Marine Engineers was held at the Engineering Societies Building, New York City, on Nov. 18 and 19, 1909. In the absence of President F. T. Bowles, Mr. Stevenson Taylor (Quintard Iron Wks., New York) presided. Also, at the annual election of officers in the course of the meeting he was chosen President (term three years), to succeed Mr. Bowles. The whole ticket elected is as follows:

President:

Stevenson Taylor.

Vice-Presidents:

J. W. Miller (Cape Cod Canal Construction Co., New York City).

George W. Melville, Rear-Admiral U. S. N., retired (Philadelphia).

Members of Council:

Wm. J. Baxter (Naval Constructor U. S. N., New York Navy Yard).

George W. Dickie (Naval Architect, San Francisco, Cal.).

W. D. Forbes (Prest. W. D. Forbes Co., New London, Conn.).

Andrew Fletcher (Prest. North River Iron Works, Hoboken, N. J.).

H. A. Magoun (V.-Prest. New York Shipbuilding Co., Camden, N. J.).

Lewis Nixon (New York City).

Associate Members of Council:

J. S. Hyde (Prest. Bath Iron Works, Bath, Me.).

C. B. Orcutt (Prest. Newport News Shipbuilding & Dry-Dock Co. New York City).

From the report of the council and secretary it appears that the society is growing satisfactorily, having now 795 members, but that its financial condition is not so good, inasmuch as the past year's operations show a cash deficit of about $1,700, and a total deficit of about $900. However, as the present assets exceed $20,000, most of which is cash or salable value, there is no immediate danger to the society's condition.

Excepting the election of officers and the presentation of the report mentioned, the whole

of the four sessions of the meeting was occupied with reading and discussing professional papers. There were 14 papers, but three of them were read by title only.

Ship Subsidies and Other Stimulants of Marine Commerce.

The leading paper on the basis of time devoted to it, was really not technical, being "The Foreign Trade Merchant Marine of the United States; Can It Be Revived?" by Mr. G. W. Dickie, of San Francisco. This described the decline of American shipping and advocated the establishment of mail subventions for a number of carefully selected routes operating vessels built, owned and manned by Americans. The author proposes to give out the subventions on competitive bids. For example, the Government would specify that a monthly service of 12-knot mail steamers is to run between, say, New Orleans and Buenos Aires, and it would receive bids for the amount of subvention demanded, the grant being made to the lowest bidder. The paper stirred up a lively discussion, though hardly any of it was favorable to purely mail subsidies.

Mr. W. M. McFarland (Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.) took the view that to build up a traffic of mail steamers only would be of little use, as the development of general freight carriers is the important thing. The proper means to develop this business should be studied by a committee of the society, which should also be charged with formulating the arguments in favor of the scheme preferred, and presenting the matter at Washington. Mr. Lewis Nixon (New York City) argued the matter out at great length, starting with the assertion that subsidies would be of no special use, in his view. He attributes the decadence of American foreign shipping to the removal of trade discriminations by this country through Congressional action and State Department agreements early in the last century, which placed America at a decisive disadvantage to all countries maintaining preferences. The work of Germany in developing its shipping during recent years was specially mentioned as an example of what is accomplished by suitable preferential treatment. Mr. E. P. Stratton (New York City) laid the chief blame for the destruction of American shipping on the refusal of the Government to indemnify marine insurance companies for war losses after the Civil War, and the resulting death of American marine insurance and the supremacy of English control and regulation. He cited several instances to demonstrate the powerful influence wielded by insurance companies, and their ability to turn trade this way or that. On the other hand, Mr. John Reid (naval architect, New York City) claimed that the position of English marine insurance is due to the fact that insurance seeks the cheapest market, which explains why even the Great Lakes shipping is all insured in England. He also asserted that Great Britain does not nurture its shipbuilding interests, but rather harasses them, and that therefore the position of English shipping should not be credited to Government support.

The upshot of the discussion was the passage of a resolution as follows:

> Whereas, the rehabilitation of the American merchant marine is essential to our commercial prosperity and independence, therefore be it resolved that a committee of seven be appointed to consider this question and suggest means by which such rehabilitation may be brought about.

The subject of building up a merchant marine was also a chief theme at the society's banquet, held on the evening of November 19.

The Screw Propeller in America.

Mr. Charles H. Cramp (Philadelphia, Pa.) presented the first part of a history of the practical application of the screw propeller in a paper, "Evolution of Screw Propulsion in the United States." He laid special stress on the invention of the propeller by John Stevens in 1804, the manufacturing reasons that prevented its use for many years, the circumstances surrounding Ericsson's introduction of the propeller, and the prompt abandonment of the latter's type of propeller, and on the connection between the use of iron in shipbuilding and the use of the propeller.

Mr. Horace See and Mr. E. A. Stevens (New York) amplified the author's statements in several points. Mr. Stevens said that John Stevens dropped the idea of using the screw for river steamers because small-scale experiments convinced him that the diameter of the screw would prove to be so large as to prevent a vessel crossing the shoals of the Hudson to reach Albany. Mr. D. W. Taylor, Prof. H. C. Sadler and others also spoke.

Model-Basin Experiments.

Mr. D. W. Taylor (Naval Constructor, U. S. N., Washington, D. C.) reported the results of an elaborate series of Washington Navy Yard model-basin experiments in a paper entitled, "The Effect of Parallel Middle Body Upon Resistance." Sixty models were tested in this work, comprising three different coefficients of fullness, and for each one five different sectional-area curves so laid out as to give five different middle-body lengths, but the same displacement. Each of the fifteen forms was tested in four sizes, 1,000 to 3,000 lbs. displacement. The tests covered a much larger range of speeds than would be obtained in practice, so they are quite general. This brief description of the scope of the tests will indicate how elaborate and tedious such work necessarily is.

It was found that at very high speeds the parallel middle body increased the resistance (i. e., the wave-making or residuary resistance, the skin friction having been deducted), but at low speeds and, in fact, all except very high speeds, the models of zero parallel body did not give the minimum resistance. For minimum wave-making resistance the parallel body should form a certain percentage of the total length; this percentage was found to be 12% to 16% for shapes whose longitudinal coefficient is 0.68, 24% to 27% for shapes whose longitudinal coefficient is 0.74, and 32% to 35% for shapes whose longitudinal coefficient is 0.80. But the limits may be increased considerably (i. e., up to 25%, 40% and 48%, respectively) with only small increase in resistance.

A related line of experimenting was reported on by Prof. H. C. Sadler (University of Michigan, Ann Arbor, Mich.) under the title, "The Influence of the Position of Midship Section Upon the Resistance of Some Forms of Vessels." His tests were made in the Ann Arbor tank. Two shapes of model were tried, each being modified by placing the section of maximum area at midlength, 5 per cent. aft, 10 per cent. aft or 10 per cent. forward, but keeping the displacement, breadth and draft constant. It developed that with low speeds the resistance is not much influenced by the position of the maximum section. At high speeds, however, the performance improves if the maximum section is moved somewhat aft of the center.

Since in Prof. Sadler's models, moving the section of maximum area aft of midlength involved also a shift aft of the center of gravity, Mr. D. W. Taylor concluded that the tests confirm what has been believed by tank experimenters for some time past, namely, that the center of buoyancy should be slightly aft of the center of length. This is illustrated by the fact that most models run better when down by the stern than when down by the head, which proves that modifying their lines so as to shift the center of buoyancy aft gives better results than the opposite modification.

Some recent theoretical work auxiliary to the experimentation at the Washington model-basin was concerned with computing pressures and velocities along the stream lines surrounding certain ship forms when in motion. Mr. William McEntee (Assistant Naval Constructor, U. S. N., Washington, D. C.) carried out these computations, which involved intricate graphical analyses according to a method developed by him. He presented the results of his work in a paper entitled, "Some Ship-Shaped Stream Forms." Naturally there was no discussion of moment.

Electric Reducing Gearing for Turbine-Driven Ships.

A very striking subject was brought up by Mr. W. L. R. Emmet (General Electric Co., Schenectady, N. Y.), who read a paper entitled "Applications of Electricity to Propulsion of Naval Vessels." In ships driven by steam-turbines, the low revolution speed required even by the highest-speed propellers makes it necessary to have turbines of very large diameter to bring the rotative velocity down to the proper point. An enormous weight reduction could be achieved if high speed turbines could be used. This is the reason for the heroic attempts to develop toothed gearing, which Rear-Admiral Melville lately brought prominently into notice. Mr. Emmet proposes to reach the same result in a very different manner, namely, by electric gearing. His turbines drive alternating-current generators, and these feed large induction motors fixed on the screw-shafts. The generators may run at very high speed, the motor (and hence the propellers) at low speed. By having multiple windings on the motors, moreover, he can change their number of poles so as to get several economical speeds. For the rest the control is by means of resistance placed in series with the rotor windings. Further, he varies the voltage of the generators by changing their excitation, and thus maintains high efficiency at all loads. His design contemplates a maximum voltage of 2,200, and a maximum frequency of 60 cycles per second.

An electric gear installation of this kind is in service on two fireboats of the city of Chicago. This is a small installation, compared with that needed on a battleship.

This system was actually designed for one of the new battleships recently contracted for by the United States Government, but the design was not made until after bids had been submitted, and did not enter into the competition. However, a combination design, half electric and half direct steam drive, had been worked out for the bidding, and a bid on it was submitted jointly by the General Electric Co. and the Fore River Shipbuilding Co. The contract was awarded for a Parsons turbine equipment, so that the electric system is not yet a reality for our navy.

The combination system which was bid on comprised a low-pressure turbine on each screw-shaft, a motor on each screw-shaft, and a generator driven by a high-pressure turbine for feeding the motor. The generator turbine is arranged to be capable of running alone or exhausting into the low-pressure; the idea was to drive by motor only, for ordinary speeds, while for high speed the low-pressure turbine was to be started up in addition, taking steam from an intermediate chamber part-way along the bucketing of the high-pressure turbine.

In discussion it was suggested that an electric gearing system rendered it possible to control the screws direct from the bridge. Reference was made to the two accidents at the Soo locks this summer, to show how many accidents would be avoided if the captain had the screws under his direct control. Mr. Emmet himself appeared to discount this proposal, however.

Mr. E. H. B. Anderson (Parsons Marine Steam Turbine Co., New York City) entered into a lengthy criticism of details of the proposed system, chiefly in defense of the Parsons turbine. An interesting statement of his was to the effect that the Parsons company made designs and estimates of a similar system three years ago, finding, however, that it would have a prohibitive weight and a very high cost. He stated also that in the battleship bids where the combination system described by Mr. Emmet competed, the bid based on the combination drive was $650,000 higher than the lowest bid covering Parsons-turbine equipment. Moreover, inasmuch as the combination drive is planned to have its low-pressure turbine normally cold, cruising speed being the normal condition for a battleship, he apprehends trouble from condensation water when steam is suddenly turned into it. This last point was disposed of by Mr. Emmet, however, with a reference to some 7,500-KW. turbines at Schenectady, which, normally idle as a power reserve,

are started in emergency at a moments' notice, with no trouble whatever.

A Producer-Gas Boat.

The motor-boat "Marenging" was built last year by Mr. H. L. Aldrich as a trial of what could be done with a gas-producer to take the place of the dangerous gasoline tank. The boat is 40 ft. long over all, 38 ft. 6 ins. on water line, 9 ft. broad and 6 ft. 3 ins. deep, drawing 3½ ft. Its gas-producer is of the suction type, and is 24 ins. in diameter by 4 ft. high. The entire producer equipment weighs 1,000 lbs.; including engine and propeller, 2,650 lbs. A four-cylinder 5¼ × 6-in. engine was used, but the compression was increased, to an amount estimated at 90 lbs. The boat ran well, and during a season's run of some 3,000 miles its power equipment gave no trouble at all. It can make nearly 900 miles at 8 mi. per hr. on one ton of anthracite coal. A no-stop run was made from New York to Albany and return, 275 miles, in July, 1909, and the fuel consumption averaged 2.31 lbs. per mile, or 15.32 lbs. per hr. These facts and figures are from Mr. Aldrich's paper, "The Producer-Gas Boat 'Marenging,'" which was read at this meeting. There was some criticism of the fuel-economy figures, in the discussion, but the absence of indicator records made this uncertain, as the power generated could only be guessed at.

Ore Unloading Machinery on the Great Lakes.

Mr. R. B. Sheridan, of the Brown Hoisting Machinery Co. (Cleveland, O.) sketched the landmarks of the remarkable development of unloading machinery at the Great Lakes ports, in which development his firm played a leading part. The subject bears on the interests of the naval architect because ship construction has been modified profoundly to meet the requirements of unloading machines.

The development up to the time grab-buckets were introduced into this service was an evolution of design of cable hoisting and transferring machinery. The transferring, however, was done by cableway only in the earliest machines, all later ones having rigid tracks for the trolley travel, and therefore braced bridges in place of simple cable spans across the stock-pile space. Steam hoisting engines were used for driving, almost exclusively. The old wheelbarrow method of unloading disappeared very quickly after the first of these unloading machines were built, and thereby about half the labor was saved. So long as the buckets or tubs had to be filled by hand in the hold of the ship, however, the cost and speed of unloading were still largely dominated by the limitations of dock labor. The period of unloading machines began about 1880. It was created by the Lake Superior iron-ore traffic, but has since captured the entire coal-unloading business at every western lake port.

For twenty years the plain bucket held the field, and then grab buckets were introduced. These eliminate most of the hand labor within the hold, being self-filling and capable of practically cleaning out the hold in a properly constructed ship. Two forms of unloader use the grab bucket, one having the bucket suspended from ropes (a hoisting rope and a bucket-closing rope), the other having the bucket rotatably fixed at the lower end of a rigid vertical leg.

To use the full possibilities of the grab bucket, it has been found necessary to construct special ships, in which the hold constitutes one clear space, a long trough, extending from tank-top to deck. The double side walls and bottom, in conjunction with stiff girders across in the deck, between hatches, form the system of framing. In these boats the hatches are continuous over the top of the hold, separated only by the deck girders and the necessary plating and hatch combing. The first vessel of this type, the "Wolvin," was built only three or four years ago. Its hold had sloping sides to slide the ore to the center, but this was found a disadvantage because the descending bucket was likely to strike the inclined plating. Later boats, therefore, have practically vertical sides. The latest are about 600 ft. long, and can carry 12,000 tons of ore.

The grab bucket of the perfected type developed for ore unloading has also found application to coal handling, both in taking out of vessels and in taking from stock piles. The ore service is its most important field, however.

In sharp contrast to this record of practical development was the next paper, a mathematical study of bending-moments in beams loaded with a non-uniform, increasing load, as affects the stiffening framing of bulkheads in ships. It was entitled, "The Strength of Water-tight Bulkheads," and was presented by Prof. Wm. Hovgaard (Mass. Inst. of Technology, Boston, Mass.). The first half of the paper dealt with beams capable of resisting only by bending, and its nature is obvious. The second part attempted an analysis of beams held longitudinally at the ends, so as to resist partly by bending and partly by suspension action. The author does not state whether he considers it proper to calculate ship bulkheads on the assumption of this condition, but the elasticity of the framing to which the bulkhead beams are attached, and the very small amount of longitudinal shortening that accompanies bending, would seem to make the assumption entirely inapplicable.

Rather more discussion than followed most of the papers was aroused by "The Design of Submarines," a paper presented by Mr. M. F. Hay. Here the controversy between plunging and even-keel submarines was again gone into, and the single-hull construction was contrasted with the double-hull or boat shaped form. The author prefers the single-hull form at all points. A stronger advocacy of this form was given by Mr. Lawrence Spear (Electric Boat Co., Quincy, Mass.) in a letter discussing the paper. The latter also stated that a later design than the No. 9 Holland mentioned by the author (273 tons, 520 B.HP., 11.6 knots) showed marked advance (300 tons, about 600 HP., over 13 knots) and reached nearly the best surface speed claimed for European double-hull submarines. The even-keel type of boat was defended in other discussions, and the use of a drop keel was also claimed a needed safeguard. The question of what value attaches to surface speed, which Mr. Spear particularly discounted, was characterized by others as an unsettled point. Prof. Wm. Hovgaard remarked that surface speed would be particularly important in larger, sea-going submarines, but these are a type not yet developed in practice.

Three papers were read by title only, "A System of Mathematical Lines for Ships," by Mr. J. N. Warrington (Honolulu, Hawaii); "Building and Equipping the Non-Magnetic Auxiliary Yacht 'Carnegie' with Producer-Gas Propelling Equipment," by Mr. Wallace Downey (New York City); and "The Development of the Gasolene Power Boat." The latter was in substance a brief description of a luxurious 83-ft. gasoline motor yacht recently built. The paper on the non-magnetic yacht "Carnegie" is worth a few notes.

Non-Magnetic Auxiliary Yacht "Carnegie."

The "Carnegie" was built for the Carnegie Institution, of Washington, D. C., as a vessel to make magnetic surveys of the seas. An essential was to avoid the use of iron and steel wherever possible, so as to eliminate the magnetic disturbance of the earth's field by the vessel.

The boat is 155½ ft. long over all, or 128 ft. 4 ins. on water line, with 33 ft. beam and 12 ft. 9 ins. depth of hull, displacing 568 tons. The materials used in the hull construction are: Oak for frames, Georgia pine for beams, Oregon pine for sheathing and spars, and teak for joiner work. Gun-metal composition was used for all the fastenings of the woodwork, except where copper was suitable. Winches, fittings and anchors are also of gun-metal, and the anchor cable is hemp.

The auxiliary power comprises a down-draft gas-producer and a four-cylinder gas-engine. The producer has a copper shell lined with firebrick and asbestos. It was necessary to make the grates and cleaning doors of iron, and here manganese steel was used, which is but slightly magnetic. Similarly in the engine it was not possible to avoid steel altogether. All parts, including shaft and propeller, are of bronze, except cams, pistons and some small parts whose service is too hard to make bronze safe. The engine is of 150-HP. capacity.

The vessel is reported to be working quite satisfactorily (the author speaks for the first two months of its service), although minor changes in the power equipment are to be made.

A paper on "Structural Rules for Ships" was presented by Mr. James Donald (Camden, N. J.). This contained a code of classification and construction, drawn up for the United States Standard Association a year ago.

Annual Conventions of the National Municipal League and the American Civic Association.

No small part of the marked improvement in municipal government and city conditions during recent years has been due to the efforts of the National Municipal League and the American Civic Association. The League was organized over fifteen years ago to promote better municipal government by investigation, discussion and publicity. The Association was formed five years ago, by the consolidation of several organizations devoted to bettering the physical and esthetic conditions of cities and villages. For several years the League and the Association have held their annual conventions at the same time and place, and have had several joint sessions for the consideration of topics of mutual interest. The conventions for 1909 were held at Cincinnati, O., Nov. 15 to 18.

Over sixty separate papers were scheduled for presentation before the two organizations. These dealt with nominations to municipal offices, campaign contributions, the initiative, referendum and recall, civil service reform, city administration, budgets, bureaus of municipal research, franchises and the regulation of public utilities, the police force, the work of boards of health; the conservation of national resources; city planning in many of its aspects, city nuisances and numerous phases of public and semi-public art.

Joint Meetings, Luncheon and Banquet.

Two evening sessions, three round-table luncheon conferences and a banquet attended by more than four hundred people were utilized to bring together the members and guests of the two associations. Conservation was much to the front at one of the joint meetings and at the banquet, while informal talks on public utilities, the work of volunteer municipal agencies and the short ballot (made short by reducing the number of elective officials) were the features of the luncheons.

CONSERVATION.—Dr. Chas. W. Eliot, Ex-President of Harvard University and President of the recently formed National Conservation Association, Hon. James R. Garfield, Secretary of the Interior under President Roosevelt, and Mr. J. Horace McFarland, President of the American Civic Association, spoke on conservation. President Eliot presented the subject broadly, but with much force and grace, bringing home to his large mixed audiences the leading features of conservation which have been presented in much detail in Engineering News during the past two years.

Mr. McFarland, under the heading "The Intimate Side of Conservation," dealt with its relations to human life, endeavor, recreation and esthetic enjoyment. He called particular attention to the neglect of health, life and comfort and convenience brought out by the Pittsburg Survey, and stated that the $7,000,000 loan recently voted at Pittsburg would be used largely to remedy defects which should never have been allowed to come into existence. Conserve natural beauty and create artificial beauty for all he urged. At the banquet, Mr. McFarland talked on "The Vulgarity of Waste," as shown by extravagance, carelessness and indifference, in things small and great.

EX-SECRETARY GARFIELD ON CONSERVATION.—From Mr. Garfield's able and well-received address we present the following extracts:

Conservation means the prevention of needless waste in production, the development of highest efficiency in use, and wherever possible, improvement, increase and replacement.

Conservation is pre-eminently a movement for the public welfare. The public welfare demands equality of opportunity for all citizens in the use of natural resources; it demands that the resources which are essential to the life of the nation, such as water, fuel and mineral phosphates, be developed and used for the public good and subject to public regulation.

In opposition to public welfare is that kind of private interest which selfishly seeks to control natural resources solely for its own benefit; and, regardless of waste or destruction, thoughtless of the future, works only for the highest immediate profit. Such private interest objects to equality of opportunity and to public regulation.

Exactly as the railroads are regulated because they are public utilities, so must the interests that develop natural resources be regulated because they deal with public interests. Unfair use or monopolization of either is intolerable.

The denudation of our forest area means the diminution of the water-supply. The administration of the Forest Service has kept this important question constantly in view and has provided for the proper use of water within the national forests under such conditions and regulations as will prevent monopoly and extortion and insure the development of water-power where and when needed.

During the past few years the immense coal areas, aggregating about 80,000,000 acres in the Western states and territories, have been reclassified and revalued and are now subject to disposition. In Alaska the coal area of about 1,000,000 acres has been withheld from entry pending investigation.

The present laws providing for the disposition of these coal lands are not what they should be. Some improvements have been made in recent years, but the rights of the public are not safeguarded. None of these lands should be disposed of until legislation is enacted which will provide a method by which the coal can be developed as it is needed, under such regulations as will prevent speculative or monopolistic holdings by a few great interests and will yield to the nation a fair money return. Under a leasing system all these conditions can be readily imposed, and these great fuel deposits can be used and the public interests fully protected.

By executive action all the mineral phosphate lands on the public domain were withdrawn from entry because it was found that the mineral phosphates now developed in this country were not only in the hands of a monopoly, but were in large measure being exported to other countries. Our soils need every ton of our mineral phosphates. We have but to look to the statistics showing the startling decrease in the productivity of our agricultural lands to appreciate the importance of conserving the mineral phosphate deposits. The depletion and ultimate exhaustion of our agricultural lands means the loss of national vitality.

Water is one of the great resources whose use does not mean its destruction. The preservation of the forests insures the preservation of the water-supply. The use of water must be so controlled as to provide for the public needs at reasonable cost, its use for irrigation or development of power is necessarily monopolistic. Therefore, such use must be strictly regulated by public authority or it will become an intolerable monopoly.

During the past few years, for the purpose of protecting the public interests great irrigation projects have been undertaken by the Federal Government and many power sites have been withdrawn from public entry. The reclamation projects will add to acres of wonderfully fertile land. Congress has wisely provided for the continued development of these projects, but there is immediate need of legislation to control the use and development of water-power to the end that, as with other resources, the public may, under the system of franchise or lease, protect its own great interests and obtain just compensation.

Executive action must be followed by legislative action. It is, therefore, necessary that the people be fully alive to the tremendous importance of the conservation problem. They must see to it that their representatives act primarily for the public interest. If the public interest be wisely cared for there need be no fear that injustice will be done to private interests.

Conservation is not limited as is often supposed to the Western states. Every state of the Union has within it resources that demand public attention. Some of the Eastern states have already acquired forest areas and are controlling watersheds. In the states where the lands have gone into the hands of private owners the regulation of the use of water may be reached through the regulation of corporations. Those states which own canals and reservoirs can provide for the development and use of water-power. Through the Agricultural Colleges each state can do much for the improvement of its agricultural lands. Laws which will safeguard the operation of mines will not only protect the lives of the miners, but will prevent unnecessary waste in production.

CHOOSING POLITICAL BOSSES.—The Hon. Chas. J. Bonaparte, President of the National Municipal League and successively Secretary of the Navy and Attorney-General under President Roosevelt, devoted his presidential address to the "Initiative in the Choice of Elected Municipal Officers," meaning thereby the initial steps in selecting candidates for popular vote at the polls. Assuming that the party boss is not eliminatable, the speaker suggested the following means of making him the choice of the party electorates: At each election each voter, while in the booth to prepare his ballot, would write on a blank prepared for the purpose his choice for boss of his party, and subsequently he would deposit this in a separate ballot box. Of the four or six men securing the highest number of votes in each party the leading man would be the party boss for the ensuing year and the others would be an advisory council or "ring." The boss would name all candidates for his party, after consulting with the advisory council or ring. If any member of the council disapproved the final choice of the boss then the member would make the fact and his reasons therefor public.

A notable feature of the speech-making at the banquet was a brief and well-considered address by Mrs. Philip N. Moore, of St. Louis, President of the National Federation of Women's Clubs, and as such representing 800,000 women. She told of many ways in which these clubs are helping in municipal reform and betterment, including very effective work for improving city milk, meat and other food supplies.

The National Municipal League.

The first independent session of the League opened with an abstract of the lengthy survey of the municipal field for the past year which is presented yearly by Mr. Clinton Rogers Woodruff, Secretary. While calling attention to the rapid increase in the number of cities organized under the commission plan of government and commending the plan for simplicity, and for concentration of responsibility, the speaker said that there was a danger that the plan would be considered a panacea for all municipal ills. A notable result of the commission plan, with its council of only five members, including the mayor and administrative department heads, is the impetus it has given to the short ballot. Recently, a Short Ballot League has been organized.

No less than 19 states now have mandatory provisions for direct nominations, besides some states in which direct nominations are permissible.

HOW TO INTEREST THE PUBLIC IN HEALTH WORK.—This subject was presented by Mr. M. N. Baker, President of the Board of Health of Montclair, N. J. The modus operandi suggested was for the local board of health to get a clear conception of its proper field of work, achieve results in one or more lines of much-needed health betterment, and then make those results known; at the same time pointing out how greater public cooperation would bring still better results in the future. Various suggestions for publicity were suggested, as were numerous agencies that might be enlisted in cooperation with local health boards.

A CIVIC REVIVAL AT GRAND RAPIDS, MICH.—Mr. John Ihlder, Secretary of the Committee on Municipal Affairs of the Grand Rapids Board of Trade, told how the board had taken up constructive work in Grand Rapids, by becoming informers rather than reformers, by calling attention to measures rather than men, and by holding a "civic revival." This revival, which extended through a week, was led by Prof. Chas. Zeublin. Among other results of the revival, which was repeated later on, a comprehensive study of city needs has been made by an expert and a plan for meeting them has been prepared.

MUNICIPAL PUBLICATIONS.—In behalf of a committee appointed to consider the advisability of the establishment of a Journal by the League Mr. Wm. B. Howland, of New York, spoke of the difficulties attending such an enterprise, and stated that the committee reported without recommendation. At the same time he submitted a list of about 150 publications, American and foreign, which give more or less attention to municipal affairs, not including those issued by boards of trade. The question of publishing a Journal was referred to the executive council of the League with power, but indications were that action to that end will be unlikely for some time to come.

INSTRUCTION IN CIVICS AND MUNICIPAL GOVERNMENT.—A number of papers and an extended discussion on this subject showed that much enthusiastic and intelligent work in this educational field is being done in the public schools, from the sixth grade on to and through the high school, and that a considerable amount of more advanced instruction in municipal government is being given in the colleges of the country. The League has standing committees which are investigating various phases of the subject.

CRUSADES AGAINST GRAFT.—A practically suggestive paper on the prosecution of grafters was read by Mr. A. Leo Weil, President of the Voters League of Pittsburg, Pa. Anti-graft campaigns should be led by small committees, having non-partisan support. Although wide support is desirable the necessity for secrecy while gaining evidence necessarily confines contributions to a few. Publicity in the early stages of a special graft campaign would mean failure. Money to carry on investigations and prosecutions must be secured before the opposing forces can begin their work.

There being no thorough supervision of the great mass of business carried on by a municipality, graft grows with opportunity and increases with immunity. An efficient organization against graft is needed. An important and generally overlooked weapon against graft is the civil suit to recover money filched from the city. Such suits do not create the sympathy for the accused or his family that results from a criminal suit, and they threaten even the most hardened grafter in a tender point—his pocket-book.

BUILDING CODES.—Anomalies in the building code of New York and of other cities were set forth by Mr. Lawrence Veiller, of New York, Secretary of the Tenement House Committee. Among the particularly bad features of the New York code is the discretionary power which it vests in the superintendent of buildings, of which there are 69 specified instances. This is a feature of many other codes. In fact, there is hardly a building code in the country which has not been modeled on the New York code, notwithstanding its many bad features. This wide copying, as was pointed out in the editorial columns of Engineering News not long ago, is due to the assumption that because New York is the largest city in the United States its building code is regarded as a model.

A building superintendent should be given full power to enforce building laws, but no power to make, amend or repeal them. There should be no board of appeal from his decisions, since that merely substitutes another power for his; but to meet rapidly changing conditions, there should be established a board to pass on new materials and processes, not recognized in the building code. This board should be composed of men of training and experience, its proceedings and rulings should be public, and its decisions should be, in effect, amendments to the code.

A PLEA FOR TRAINED MEN IN THE MUNICIPAL SERVICE.—Under the caption, "Taking Municipal Contracts out of Politics," Mr. Richard H. Dana, of Cambridge, Mass., made a strong plea for the adoption of some plan by which men fitted for their various lines of work would be placed and kept in office. He did not undertake to say just how it should be done in the United States, but he did outline successful methods to that end employed in Europe.

REFERENDA VOTES IN MASSACHUSETTS FOR OVER A HUNDRED YEARS.—That the referendum, or giving the people of city or state a deciding vote on constitutional and charter amendments and legislative acts in general, is not a new thing was shown by Dr. Edward M. Hartwell, Secretary of the Boston Statistics Department. In general, the people of Massachusetts in state matters, and of Boston in city matters, have shown both interest and discretion in referendum votes, which began in 1776 on the question whether a declaration of independence of Great Britain would be advisable and have continued

until the vote on Boston charter amendments, on Nov. 2, 1909.

STREET RAILWAY FRACHISE QUESTIONS.—The question of city transit, with special reference to conditions in New York, Chicago and Cleveland, was presented in an interesting group of papers. One of these, by Mr. Hoyt King, of Chicago, outlined the recent street railway settlement in that city, under the terms of which a conflict of many years' standing has been brought to a close, and the city is now receiving a very large annual revenue in the way of 55% of the gross receipts of the consolidated companies, besides having a very considerable measure of control of the street railways of the city through an expert commission headed by Mr. Bion J. Arnold.

Mr. Milo R. Maltbie, a member of the Public Service Commission for the First District of New York, sent a paper entitled, "A Progressive Rapid Transit Policy." He outlined the features of what is known as the indeterminate franchise, or the grant subject to revocation by the municipality. This plan has long been in operation in connection with legislative street railway grants in Massachusetts and has recently become effective in Wisconsin by a permissive provision of the new publicity law there, which makes it possible for any private-service corporation operating under a municipal franchise to substitute an indeterminate for a specific franchise and to gain certain advantages thereby. Mr. Maltbie also outlined a plan under which a city might share the profits of street railway and other franchise companies when they exceeded a certain percentage on the investment, and he also outlined a proposed system for the construction of rapid transit extensions in New York on the assessment-for-benefit plan. This plan would be similar to one which has been followed in many cities for years past in connection with street and sewer extensions. It is fairly comparable with a sewer assessment plan, where the assessments are made by drainage districts. Under the policy that has prevailed in the past in New York City, the large expenditure required for a very extended line of rapid transit benefiting a relatively narrow strip has inured greatly to the benefit of real estate and property generally along the strip, particularly in the remote sections of the city reached by the rapid transit line; but it has made such inroads upon the city funds as to make it difficult to secure extensions to other remote points which are equally in need of rapid transit facilities. The situation becomes all the more pointed when it is remembered that the 5-ct. fare which carries passengers to the distant Bronx does not pay the cost of transportation, although it has "boomed" real estate in that section to a remarkable degree. Raising the cost of rapid transit or rapid-transit extensions to remote points by means of assessment would help distribute the burden and at the same time make possible the more rapid extension of the service to all parts of the city.

An earnest and, on the whole, an apparently successful, attempt to present an impartial review of the Cleveland street railway campaign waged during the seven or eight years of the mayoralty of Mr. Tom Johnson, was made by Mr. W. S. Hayden, of Cleveland. Summing up, it appears, from what Mr. Hayden said, that in his opinion the net result of the bitter conflict at Cleveland had been the establishment of the principle that charges for street railway service in Cleveland hereafter should be based on cost of service, including 6% on the valuation of the system; that fares would probably be 2.4 mills per ride lower than those offered by the company seven years ago, totaling $1.46 for two rides a day for 305 working days; that the securities of the street railways have been depreciated in value; and that there has been seven years of war, which has done much harm in various ways, including its bad effect upon general business. Mr. Hayden appeared to be decidedly of the opinion that the results attained in the way of benefit to the people would not be worth what they had cost in the way of damages to various interests. It may be added that it appears from Mr. Hayden's statements that the conflict will soon come to an end, since apparently all that remains to be settled is the valuation to be put upon the street railway property of the city. This valuation is being fixed by or under the direction of Judge Taylor, a Judge of the United States Courts, who has already arrived at a settlement of the other features of the necessary agreement between the city and the street railway interests.

MUNICIPAL BUDGETS, in the abstract and concrete, were discussed by Mr. L. G. Powers, of the Bureau of the Census, and Mr. Alonzo Tweedale, Auditor of the District of Columbia. Mr. Powers stated, among other things, that municipal budgets as now made up give the people no efficient control over city expenditures, and the financial statements now called budgets should be replaced by real budgets, readily understood by any intelligent citizen. Such budgets should include detailed estimates of receipts as well as expenditures during the year covered, and the receipts should disclose their origin; that is, whether from taxation, licenses, earnings on revenue-producing municipal industries, loans, etc. Mr. Powers stated that a budget has been prepared for the District of Columbia for the coming fiscal year, based on new and intelligent lines and in harmony with the accounting plan of the National Municipal League. If this Washington budget is put into effect it will serve as a model for other cities of the nation.

Mr. Tweedale outlined the proposed Washington budget, and showed how confusing the appropriation bills passed by Congress for the District of Columbia have been in the past. For instance, there has been one item for street improvements which included money for nine different objects of expenditure, some of which have no relation to streets whatever. A resolution was presented to the League, and adopted, in which the principle of scientific budget-making was endorsed, the efforts of the District Auditor and Commissioners to secure a proper budget for Washington approved, and Congress urged to make its future appropriation bills conform to the budget plan which has been worked up by Mr. Tweedale and which the District Commissioners much desire to see endorsed.

MUNICIPAL RESEARCH BUREAUS. — Mr. Rufus E. Miles, Director of the Cincinnati Bureau of Municipal Research and formerly connected with a similar bureau in New York, outlined the reasons for establishing such bureaus and the work which they are undertaking. He stated that the general lack of popular participation in municipal government demands new agencies to ensure municipal efficiency. Until recently, activities to this end centered in civil service reform which related to appointment of men to minor offices and to the work of municipal voters' leagues, which generally had had to do with the selection of candidates for higher offices. As a rule, there has been no means of seeing that the men chosen by whatever means did good and efficient work after once being put in office. The bureaus of municipal research which have been established at New York, Philadelphia, Cincinnati and Memphis, and are proposed in some other cities, seek to establish the principles which must be followed in carrying on municipal work so as to produce efficiency. Checks on efficiency are suggested and campaigns of publicity and education are proposed. The New York bureau, which began work in 1906 under another name, with a budget of only some $12,000, has continued its work to date with largely increased appropriations after the first year. Thus far it has been instrumental in securing the adoption of a newly centralized accounting system for New York City, a considerable reorganization of the Department of Finance, and great improvements in the municipal budget. The Department of Health has been largely reorganized and strengthened, particularly in its administrative and financial methods. Important studies of the Police, Park and Water-Supply departments have been made, and also an extensive investigation of the borrowing power of the city. The various bureaus of municipal research are dependent wholly upon public support, which generally comes in the way of relatively large contributions from a comparatively small number of people, and the bureaus make use of small forces of experts in municipal administration and accounting.

THE BOSTON FINANCE COMMISSION.—An outline of the reasons for establishing a Boston finance commission a few years ago, and the valuable work of investigation which it did, was presented by Mr. Harvey N. Shepard, Lecturer on Municipal Government in Boston University. The work of this commission has already been so fully set forth in our columns that it is unnecessary to review it again here. It is interesting to note, however, that Mr. Shepard is not a believer in the new form of government which is to go into effect in Boston early next year, but prefers, instead of a small council, a very large representative body. He also suggested that the Boston Metropolitan District be provided with a large representative governing body, something like the London County Council.

THE COMMISSION FORM OF GOVERNMENT TO DATE.—A valuable summary of the commission plan of government, with some critical comments, was presented by Mr. Ernest S. Bradford, of Washington. This plan has been adopted by 45 cities, and is under serious consideration by as many more. The commissions usually consist of five members, including the mayor. The new Houston charter has the unique feature of giving the mayor the veto power over the acts of the commission or council, and of permitting the mayor to vote on sustaining his own veto. The succession of this plan of government depends largely upon one's definition of success. In general, improved city conditions have followed its adoption, but with the exception of Washington, D. C., the plan has been tested only since its adoption, under peculiar conditions, at Galveston in 1901.

MUNICIPAL GOVERNMENT CHANGES IN MICHIGAN AND IN OHIO.—Home-rule powers granted to cities of Michigan under recent constitutional amendments were reviewed by Mr. Guy A. Miller, of Detroit, a member of the Michigan House of Representatives. These constitutional changes are calculated to give Michigan cities greater freedom from legislative control and interference than have perhaps been enjoyed before anywhere else in the country, at least by any considerable number of cities.

Important amendments to the municipal code of Ohio, recently enacted, were outlined by Mr. John R. Schindel, of Cincinnati. As some of our readers will remember, the whole scheme of municipal government in Ohio was overturned by a State Supreme Court decision in 1901. This decision, and subsequent legislation in accordance with it, wiped out the minute classification of cities that prevailed in Ohio and that led to much pernicious special legislation. Under the code of 1902, all municipalities fell into either a city class or a village class, each with its own form of government, which was the same throughout the state. It was thought by many that cities like Cleveland, which had been working under a centralized and differentiated form of city government, with a mayor having large powers, suffered materially from the change. It appears that under the recent amendments the mayors throughout the state will have large powers and responsibilities, and that the executive departments under the mayor will be lessened in number so as to include the departments of public service and of safety alone. The single heads of these two departments, combined with the mayor, will form the board of public control, and this board will have the letting of all contracts over $500 in value, under recommendation from the responsible director. Village councils will consist of seven members, but the city councils will have much larger membership, chosen for the most part at large. A considerable measure of civil service reform is introduced in the new code, but not all that is considered desirable by the most interested people. More would also be desirable in the way of separation of legislative and administrative functions, and in recognition of the fact that the city is a business corporation.

American Civic Association.

The topics presented at the joint sessions of the two organizations have already been men-

tioned in this report. Two sessions of the association were devoted to city planning. Mr. John Nolen, of Cambridge, Mass., presented the subject of city planning in its relation to the civic spirit. A paper by Mr. Warren H. Manning, of Boston, Mass., told how a new and model town, named Gwinn, had been created in "the primeval forests of Northern Michigan." The park and boulevard system of Kansas City, Mo., planned under the direction of Mr. George E. Kessler, of Kansas City, was outlined by him. Mr. L. A. Ault, President of the Board of Park Commissioners of Cincinnati, outlined plans now under way for a comprehensive park system for that city. The civic center movement at Denver, which will start in the vicinity of the state capitol, was presented by Mr. Henry Reed, Chairman of the Denver Municipal Art Commission. Other phases of the subject were presented by Messrs. William E. Harmon, of New York; Richard B. Watrous, of Harrisburg, and Harold A. Caparn, of New York. Mr. Caparn dealt at length with water fronts.

Another session of the Civic Association was devoted to the billboard nuisance and its abolition, and still another to noise and smoke nuisances, these two sessions being labeled First and Second Conferences on Nuisances, respectively. Mr. Matthew Nelson, of Cincinnati, O., appeared on the program with a paper on "Smoke Abatement in Cincinnati," and Mr. R. C. Harris, of Toronto, Canada, Secretary of the National Association for the Prevention of Smoke, took up the larger subject, "Smoke Abatement in America." Mr. Harris dealt not only with work in the country at large, but also with efforts and achievements at Toronto. Dr. Charles A. L. Reed, President of the Smoke Abatement League of Cincinnati, was scheduled for a paper on "The Smoke Nuisance and Its Relation to Health."

THE ECONOMICS OF SMOKE.—Mr. H. M. Wilson, M. Am. Soc. C. E., of Washington, D. C., Chief Engineer of the Technologic Branch of the U. S. Geological Survey, made the somewhat startling assertion that damage and waste by smoke in the large cities of the United States alone caused a loss that might be conservatively estimated at half a billion dollars. How this conclusion was reached is shown in part by the following extracts from the paper:

> In our great and middle-sized cities live more than 30,000,000 people, and these suffer all the loss shown in the total of $500,000,000. This means a per capita loss of $17 each year to every man, woman and child in these cities.
>
> These figures are so astounding as to be almost unbelievable, and it is but fair to tell on what this estimate was based. A short time ago smoke officials of Chicago, after careful inquiry, reported that that city lost $50,000,000 each year through smoke. Cleveland, Ohio, conducted a similar inquiry among its merchants and placed the smoke damage at $4,000,000. St. Louis, Mo., in estimating the damage on merchandise alone gave it at $1,000,000. The city of Harrisburg, Pa., showed $120,000 loss for the year.

Further estimates on financial losses due to smoke, together with suggestions for eliminating them and the smoke nuisance at the same time, were as follows:

> Our present method of burning coal with smoke is costing the people of this country unnecessarily $90,000,000. It is estimated that 8% of the coal used in the production of power, light and heat, or in all about 20,000,000 tons of coal, are going up the chimneys each year in smoke. This coal cost the people at least $40,000,000. It is further estimated that in the production of coke 25,000,000 tons of coal are wasted in the air. This coal is worth $50,000,000.
>
> While this total loss of $90,000,000, due to imperfect combustion, added to the losses due to damaged property, aggregates a vast sum, it is as nothing compared with the injury which the smoke inflicts to life in the great cities. The smoke nuisance means uncleanliness, wretchedness, disease and death. Comparing physical and vital assets as measured by earning power, vital assets are three to five times the physical assets.
>
> Aside from the possibility of remodeling existing plants, the secret of all smokeless combustion of coal in the future lies in four directions. First, as large plants may, for obvious reasons, be operated more economically than smaller ones, the concentration of the functions of the latter in central plants in cities offers a solution of the problem of producing power, light and heat at a reasonable price and without smoke. Second, the conversion of coal into producer gas and the utilization of the latter in power production by gas engines both in small independent installations and large central generating stations.
>
> Third, the compressing of bituminous slack and lignitic coals into briquets which can be burned in locomotives and domestic furnaces with less smoke than the raw coal.
>
> Fourth, the coking of coal in by-product instead of in common behive ovens, thereby eliminating smoke and saving the gases and distillates for power production and industrial use.
>
> Altogether, the situation is hopeful. The smokeless city in the future is to be the note of civilization; a smoky city is to be the sign of barbarism, and not the badge of prosperity some have boasted it. The few agitators for emancipation from the evil of soot of a few years ago have been re-enforced by a vast army of crusaders.

BEAUTY AND GOOD TASTE IN REAL LIFE.—Under this heading there were presented a number of short papers and addresses on such topics as art and the garden, household decoration, art and the railroad, the art exhibits for the people, and municipal art in Cincinnati.

At another session Mr. John Nolen, who has recently been doing some important work in connection with the state park system of Wisconsin, presented a paper entitled, "Beauty of Nature as a State Resource."

A List of Permissible Explosives for Use in Coal Mines.

The accompanying list of permissible explosives for use in coal mines, issued by the U. S. Geological Survey, embodies the results of tests carried on at the explosives testing gallery at Pittsburg, Pa. The test conditions and requirements and a description of the testing gallery were published in Engineering News, Jan. 21, 1909, p. 86. The list includes only those explosives of which the chemical and physical tests showed no unfavorable results; which have passed tests No. 1 and No. 3 (see reference above); and of which 1½ lbs. have been fired into the mixture of gas, air and dust as prescribed for test No. 4.

The publication of such a list by the Geological Survey does not of itself authoritatively prohibit the use of explosives which could not pass the tests, but it is expected that this may be its ultimate practical effect through its adoption by mine workers and owners.

The permissibility of the explosives listed is subject to four provisions as follows:

1. That the explosive is in all respects similar to sample submitted by the manufacturer for test.
2. That No. 6 detonators, preferably No. 6 electric detonators (double strength), are used of not less strength than 1 gm. charge, consisting by weight of 90 parts of mercury fulminate and ten parts of potassium chlorate (or its equivalent), except for the explosive "Masurite M. L. F.," for which the detonator shall be of not less strength than a 1½-gm. charge.
3. That the explosive, if frozen, shall be thoroughly thawed in a safe and suitable manner before use.
4. That the amount used in practice does not exceed 1½ lbs. (680 gms.), properly tamped.

PERMISSIBLE EXPLOSIVES TESTED PRIOR TO OCT. 1, 1909.

Brand.	Manufacturer.
Ætna coal powder A.....	Ætna Powder Co., Chicago
Ætna coal powder AA.....	Do.
Ætna coal powder B.....	Do.
Ætna coal powder C.....	Do.
Bituminite No. 1.....	Jefferson Powder Co., Birmingham, Ala.
Black Diamond, No. 3....	Illinois Powder Manufacturing Co., St. Louis, Mo.
Black Diamond, No. 4.....	Do.
Carbonite No. 1.....	E. I. Du Pont de Nemours Powder Co., Wilmington.
Carbonite No. 2.....	Do.
Carbonite No. 3.....	Do.
Carbonite No. 1-L. F....	Do.
Carbonite No. 2-L. F....	Do.
Coalite No. 1.....	Potts Powder Co., N. Y. C.
Coalite No. 2-D.....	Do.
Coal Special No. 1.....	Keystone Powder Co., Emporium, Pa.
Coal Special No 2.....	Do.
Collier dynamite No. 2....	Sinnamahoning Powder Mfg. Co., Emporium, Pa.
Collier dynamite No. 4....	Do.
Collier dynamite No. 5....	Do.
Giant A low-flame dynamite	Giant Powder Co. (Con.) Giant, Cal.
Giant B low-flame dynamite	Do.
Giant C low-flame dynamite	Do.
Masurite M. L. F.....	Masurite Explosives Co., Sharon, Pa.
Meteor dynamite	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Mine-ite A.....	Burton Powder Co., Pittsburg, Pa.
Mine-ite B.....	Do.
Monobel	E. I. Du Pont de Nemours Powder Co., Wilmington, Del.
Tunnelite No. 5.....	G. R. McAbee Powder & Oil Co., Pittsburg, Pa.
Tunnelite No. 6.....	Do.
Tunnelite No. 7.....	Do.
Tunnelite No. 8.....	Do.

The differences between the permissible explosives as a class and the black powders were noted in Engineering News, June 17, 1909, p. 676.

A TENEMENT HOUSE FIRE in East New York, N. Y., Nov. 23 caused the death of five of the tenants. The tenement was a four-story frame building at 1[illegible] Herkimer St. and was occupied by about 50 persons. The fire started on the ground floor shortly before midnight and had cut off escape by the stairways before it was discovered. The building was entirely destroyed.

A lodging house burned in Pittsburg, Pa., Nov. 14, and three persons lost their lives in the fire. The building was a two-story brick structure.

THE STEAMER "ST. CROIX" WAS BURNED AT SEA Nov. 20 near Santa Monica, Cal. When the vessel was close to the shore, still burning, a series of explosions occurred which broke up the hull. The "St. Croix" was 240 ft. long, with a registered gross tonnage of 1,960. She carried a crew of 59 men and about 390 passengers, all of whom were landed in the small boats.

THE FIRE IN THE ST. PAUL MINE AT CHERRY, Ill., in which 300 men were entombed by the explosion of Nov. 13, as noted in our last week's issue, had subsided sufficiently Nov. 17 so that the air-shaft was unsealed and two men equipped with oxygen helmets descended into the mine. They were unable to accomplish more than an exploration of the shaft itself on account of the smoke and steam.

On the 18th, however, a second descent was made and the bodies of 20 men were found near the air-shaft. One of these bodies was brought to the surface. The air-shaft was then closed and a stream of water directed into it, after which the main shaft was opened and men in helmets descended to the second level where the fire started. Later it was found possible for a squad of unhelmeted men to enter the mine and an attack was begun upon the fire with a hose. The search for bodies was impeded by debris left by the explosion.

On Nov. 19, four more bodies were recovered and further progress was made in extinguishing the fire and clearing the gangways.

Twenty-one men were found alive in the mine, Nov. 20, one week after the explosion. One of these died before being brought to the surface and another died three days afterward. The rescued men had retreated to a remote part of the mine and had made a barricade to keep out the poisonous gases. When found by the rescue party they had come out from their barricades in search of water.

A number of dead bodies were removed from the mine Nov. 20-22 but no more were found Nov. 23. The number originally entrapped in the mine is given in recent reports as 310. Of these, 19 escaped alive and 101 dead bodies have been found. This leaves 189 miners still unaccounted for.

A COAL MINE EXPLOSION in the Florence mine of the Youghiogheny & Ohio Coal Co., near Martin's Ferry, Ohio, Nov. 21, severely burned six miners. The six injured men were brought to the surface alive but are not expected to survive. The mine was heavily damaged.

THE BRITISH BATTLESHIP "VANGUARD" on Nov. 23 developed in a trial trip of eight hours a speed of 22.4 knots, which is a trifle above the 22.23 knot record for ships of the "Dreadnought" class previously held by the U. S. S. "North Dakota," as reported in our issue of Nov. 11, 1909, p. 533.

THE EXTENSION OF THE NEW YORK BARGE Canal system to connect with Cayuga and Seneca lakes was submitted to popular vote at the election on Nov. 2. The result of the vote, however, has not yet been determined. The proposition on which the voters passed was whether the state should issue bonds to the amount of $7,000,000 to meet the cost of the proposed extension of the canal system. A despatch from Ithaca on Nov. 21 stated that the total returns from 42 counties showed a majority against the canal proposition of 18,784. Returns from 14 counties are not yet completed, which includes the four counties in New York City, where the vote is expected to be in favor of the canal proposition. The proposition was placed upon the ballot in such a way that few voters were able to understand and vote intelligently upon the project, and only a small proportion attempted to vote upon it at all.

AN ADDITION TO THE CORPS OF ENGINEERS is again recommended by Gen. W. L. Marshall, Chief of Engineers, in his annual report. He states that while

there are now 183 commissioned officers in the Corps, only 48 of them are under the specific control of the Chief of Engineers. Including those in the head office at Washington, only 68 officers in all are available for river and harbor work. Notwithstanding the fact that the amount of river and harbor work has greatly increased in the last ten years, and a much larger increase is probable in the future, the number of officers available for carrying on such works is less now than ten years ago. The increase in the membership of the Corps has been practically entirely absorbed in military duties arising from the increased size of the regular army.

APPROPRIATIONS FOR RIVER AND HARBOR IMprovement for the year ending June 30, 1911, are recommended by the Chief of Engineers, Gen. W. L. Marshall, as follows:

Under continuing contracts, including the Mississippi River Commission	$9,194,428
Rivers and harbors	27,038,037
California Debris Commission	15,000
Prevention of deposits in New York Harbor	100,250

It is currently reported, however, that the $36,000,000 thus asked for will be cut down by the Secretary of War to about $16,000,000.

THE CANADIAN BUDGET FOR 1910-11 shows total appropriations of $127,670,000, an increase of about $16,000,000 over the appropriations of the current year. Included in the budget is $27,000,000 for the continuance of work on the National Transcontinental Ry. and $180,000 for the survey of a railway to Hudson Bay. There is also an appropriation of $1,000,000 toward the construction of the Quebec Bridge.

THE GRAVEL-ROAD BOND LAW of Indiana, enacted in 1905, was declared unconstitutional by the State Supreme Court on Nov. 19. Under this law, bonds for road construction have been issued by the various counties of the state, amounting to $25,000,000 to $50,000,000. The effect of the decision upon the validity of these bonds is in doubt. A large amount of work now in progress under the law has come to a stop. Many contractors are seriously affected by the decision, as it is uncertain whether they can obtain any further payments for the work that they have in hand.

THE PENNSYLVANIA TUNNEL SYSTEM from Harrison, N. J., to New York City and Long Island was traversed by the first official train on Nov. 18. President McCrea of the Pennsylvania R. R., Vice-President Rea and a number of other officials and guests made the trip. As the electric equipment is not ready, a steam locomotive had to be used. The tunnels themselves are completed, but work is still in progress on the New York terminal station and the Long Island yard, and the electric line equipment is yet to be placed. The company has stated recently that the whole system will be opened to traffic by June, 1910.

THE CRIMINAL COURTS BUILDING in New York City, which was vacated by emergency order of the Bureau of Buildings on Nov. 3 as unsafe, was again occupied during the past week, after extensive shoring and sheeting had been done in the interior and at the openings in the walls. This procedure followed the recommendations of a committee of the city's engineers appointed to report on the condition of the structure, as noted in our issue of Nov. 11, 1909.

A TUNNEL CAVE-IN STOPPED TRAFFIC at Coram, Cal., on the Southern Pacific, Nov. 1. The fall was extensive enough to require nearly two weeks work with a large force to restore the timbering. During the interruption passengers and baggage were transferred around the tunnel by wagon, while through freight traffic was discontinued.

THE ST. LOUIS MUNICIPAL BRIDGE is to be of nickel-steel, according to the contract award made after receiving competitive bids on Nov. 16. Bids were required on two arrangements, one having nickel-steel eyebars and carbon-steel compression members, the other having both eyebars and compression members made of nickel-steel, the floor being of carbon steel in both. The low bidder, the American Bridge Co., made the same figure for both arrangements, $1,393,931; the pound price for additions or deductions under this bid was 5.6 cts. for nickel-steel and 3.95 cts. for carbon-steel. The other bidders, Pennsylvania Steel Co. and McClintic-Marshall Construction Co., named prices, respectively, $40,000 and $100,000 higher for the nickel steel arrangement than for the carbon-steel arrangement.

These bids cover the superstructure of the three river spans, each 668 ft. long c. to c. of end pins. They are simple Pratt trusses with sub-panels, the depth of truss at center being 110 ft. There are to be two decks, the upper carrying a 30-ft. roadway, with sidewalks bracketed outside the trusses, and the lower floor carrying two railway tracks.

Work on the piers was started recently. They will be of concrete with stone facing, founded on caissons sunk about 90 ft. below low water to rock. The substructure is being built by the Missouri Valley Bridge & Iron Works. Boller & Hodge, of New York City, are engineers for the entire work.

AN UNLOADER BRIDGE WAS BLOWN UP at the plant of the Corrigan & McKinney Co., Cleveland, O., on Nov. 4. It is supposed that a large charge of nitroglycerine was placed at the base of the tower in the night and set off. The structure was overthrown and practically ruined. It is believed that this outrage is of the same kind as the dynamiting of four buildings simultaneously in Indianapolis a few weeks ago, and the subsequent attempt to dynamite one of the city's bridges there, after the Mayor had proclaimed a reward for the apprehension of the parties responsible.

OFFICIAL RECOMMENDATION OF MOVING PLATforms is contained in a report by Mr. H. B. Seaman, Chief Engineer of the Public Service Commission of New York City, to the Commission, upon a proposal by the Continuous Transit Securities Co. to bid for an installation in a subway. Mr. Seaman reports that:

> The details of the mechanism may be so designed as to be practically noiseless. The designs and estimates indicate that as a means of transportation this method of conveyance will be efficient, safe and reliable, and, with dense traffic, most economical.
>
> The economy results from the greater passenger capacity of the moving platform over a train system, which Mr. Seaman in his report illustrates by a specific example. He concludes that it is desirable to lay out a subway route as requested by the company, and call for bids, with a view to securing an early installation. He recommends as the preferred type of subway for this purpose one having a continuous passage or "arcade" on either side of the set of platforms along the buildings fronting on the street.

THE PORT OF MONTREAL was the subject of a recent address before the Canadian Club of Montreal by Mr. G. W. Stephens, President of the Montreal Harbor Board. Mr. Stephens stated that this port now has a larger monthly business than either Boston, Galveston or New Orleans, and transacts more business in seven months than Philadelphia, Baltimore or San Francisco do in twelve. A radical plan for the further improvement of Montreal's port facilities has been developed by a board of eight Canadian engineers. By this plan the capacity of the port will be doubled and the cost of handling business through it will be greatly reduced. It is expected that about $12,000,000 will be required to carry out the plan, and twelve years will be consumed in the development.

SWELLING OF CAST-IRON from repeated heating and cooling was observed and measured by Mr. A. E. Outerbridge, Jr., four or five years ago. Recently Profs. Rugan and Carpenter, of Manchester, England, studied the matter to determine its cause. White cast-iron with low silicon, manganese, sulphur and phosphorus showed little change of volume. Gray iron, however, always showed the typical expansion, and those white irons which became gray through the annealing action also showed it after the conversion began. However, further tests showed that the graphitic carbon is not primarily concerned but that silicon is responsible, the expansion being proportional to the silicon percentage, in a series of samples having constant carbon. The investigators conclude that the action of air, fire gases and even the gases occluded in the metal, sets up the formation of compounds of silicon with the gases, and in this way causes the expansion. The volume-increase is always accompanied by an increase in weight, but the latter is much smaller than the increase in volume.

Personals.

Mr. F. Walker has been appointed Division Superintendent of the Canadian Pacific Ry., with headquarters at Nelson, B. C.

Mr. Chas. H. Paul, M. Am. Soc. C. E., has been appointed Project Engineer of the Minidoka Project, U. S. Reclamation Service.

Mr. H. L. Cumming has been appointed Chief Engineer of the Tehuantepec National Ry., with office at Rincón Antonio, Oaxaca, Mex.

Mr. J. F. Enright has resigned his position as Superintendent of Machinery of the International & Great Northern Ry. to enter the service of another company.

Mr. David E. Thompson has become President of the Pan-American R. R., and Mr. E. M. Wise, formerly Assistant to the President, has been made Vice-President and General Manager.

Mr. George Dyer, Superintendent of the Lake Erie & Western R. R., at Lima, Ohio, has resigned on account of his election to the office of Mayor of that city. His resignation is effective Dec. 15.

Mr. Earle K. Knight, Assoc. M. Am. Soc. C. E., is now employed with the firm of Hazlehurst & Anderson, consulting engineers, Atlanta, Ga. Mr. Knight was married Oct. 2 to Miss Florence Muecke, formerly of Camaguey, Cuba.

Mr. P. L. Price, Assoc. M. Am. Soc. C. E., has resigned his position as Structural Engineer with the American Bridge Co. to become Chief Engineer for the firm of Geo. B. Post & Sons, architects, 347 Fifth Ave., New York City.

Mr. Joseph Jacobs, Assoc. M. Am. Soc. C. E., Consulting Engineer, U. S. Reclamation Service, has opened an office for private practice at 406 Central Bldg., Seattle, Wash. Mr. Jacobs recently returned from Porto Rico where he had been engaged in special work for the Reclamation Service.

Mr. Washington Hull, a prominent architect of New York City, left Lawrence, Long Island, Nov. 3, in his 32-ft. yacht for Bayonne, N. J. Neither he nor his boat has been seen since that day. The body of one of the crew of the yacht was found floating in Jamaica Bay, Long Island, Nov. 23.

Mr. J. Niblock, Superintendent of the Canadian Pacific Ry., at Calgary, Alta., has retired after 30 years in the service of this railway. He has been succeeded by Mr. C. S. Maharg, formerly Superintendent at Medicine Hat, Alta., who in turn is succeeded by Mr. J. G. Taylor, Superintendent at Moose Jaw, Sask. Mr. W. J. Uren, Superintendent at Brandon, Mass., has been transferred to Moose Jaw and is succeeded at Brandon by Mr. J. A. MacGregor, formerly Superintendent at Souris, Man.

Obituary.

John Caldwell, Treasurer of the Westinghouse Airbrake Co., died Nov. 23 in his office at Wilmerding, Pa.

Robert M. Van Arsdale, Publisher of the "American Engineer and Railroad Journal," died Nov. 24 at his home in New York City, aged 61 years.

Robert J. Lucas, a civil engineer in the employ of the City of New York, was killed Nov. 19 by an express train on the Putnam division of the New York Central & Hudson River R. R. at Albany Ave. and 231st St., New York City. He was 25 years old.

George E. Merchant, President of the Rochester & Pittsburg Coal & Iron Co. and formerly General Superintendent of the Buffalo, Rochester & Pittsburg Ry., died Nov. 23 at Rochester, N. Y. Mr. Merchant was born at Worcester, Mass., in 1842. He entered railway service in 1865 as an agent of the Illinois Central R. R. In 1880-81 he was Superintendent of the Sioux City and Dakota divisions of the Chicago, Milwaukee & St. Paul Ry., and from 1881 to 1888 he was General Manager of the Rochester & Pittsburg R. R. and its successor, the Buffalo, Rochester & Pittsburg Ry. From 1892 to 1899 he was Assistant to the President of that railway and he became General Superintendent in 1899. He had been President of the Rochester & Pittsburg Coal & Iron Co. since 1888.

Engineering Societies.

COMING MEETINGS.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Dec. 2-4. Annual convention at Milwaukee, Wis. Secy., James C. Monaghan, 20 West 44th St., New York City.

NEW JERSEY SANITARY ASSOCIATION.
Dec. 3-4. Annual meeting at Laurel-in-the-Pines, Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 6. Annual meeting in New York City. Secy., Wm. H. Ross, 154 Nassau St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 7-10. Annual meeting at New York City. Secy., C. W. Rice, 29 West 39th St., New York City.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 8-10. Annual meeting at Philadelphia, Pa. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 14-15. Annual meeting at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 14-16. Annual convention at Washington, D. C. Secy., Glenn Brown, The Octagon, Washington, D. C.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27. Annual meeting at Boston, Mass. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 28-29. Annual meeting at Ames, Iowa. Secy., L. W. Chase, University of Nebraska, Lincoln, Neb.

MONTANA SOCIETY OF ENGINEERS.
Jan. 6-8. Annual meeting at Butte, Mont. Secy., Clinton H. Moore, Butte, Mont.

MICHIGAN ENGINEERING SOCIETY.
Jan. 12-14. Annual meeting at Lansing, Mich. Secy., Alba L. Holmes, 574 Wealthy Ave., Grand Rapids, Mich.

INDIANA ENGINEERING SOCIETY.
Jan. 13-15. Annual convention at Indianapolis, Ind. Secy., Chas. Brossmann, Union Trust Bldg., Indianapolis, Ind.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
Jan. 18-20. Annual meeting at New York City, Secy., W. M. Mackay, P. O. Box, 1818, New York City.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 19-20. Annual meeting at New York City. Secy., Chas. W. Hunt, 220 West 57th St., New York City.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 25-27. Annual meeting at Ottawa, Ont. Secy., C. H. McLeod, 413 Dorchester St. West, Montreal, Que.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 26-28. Annual meeting at Cairo, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago, Ill.

WESTERN SOCIETY OF ENGINEERS.—At a meeting held at the society's rooms in Chicago on Nov. 17 a paper on "The Smoke Problem of Chicago" was read by Mr. Paul. P. Bird, Chief Smoke Inspector for the city. Mayor Busse, soon after his election, appointed a Smoke Abatement Commission, and on its recommendations a new ordinance was prepared and passed in July, 1907. This created a smoke inspection department and provided that the head of the department and his principal assistants should be mechanical engineers. A special feature of the ordinance is in requiring that plans for new steam plants or alterations to old plants must be approved by the smoke department. In 1908, a board of advisory engineers was appointed by the smoke abatement commission.

Investigations made in 1907 showed that there were about 17,000 boilers, 13,000 smokestacks and 5,500 high-pressure steam plants. In many newly designed stationary plants it was relatively easy to reduce smoke production to a minimum, but this was not the case with locomotives and steamboats. It was realized that the work must be largely educational, and when complaint is filed against any offending plant, the department points out the reason why smoke is being made and allows time for improving the conditions before entering suit.

Mr. Bird claimed that the smoke had been reduced considerably by the railways and in the stock-yards district, but the greatest difficulty is with the river boats. After two years of this policy, the department is becoming more strict, especially as there is a much stronger public opinion in favor of the reduction of smoke. It is expected that marked improvements will be effected during the next two years. It was pointed out that many men who enter complaints against certain plants are themselves owners or managers of other plants which are a source of complaint.

The department has been criticized for giving engineering advice, but Mr. Bird explained that while it recommends owners to employ consulting engineers to devise improvements to their power plants very little work is handled in this way. In 75% of the cases that came up the department finds it necessary to facilitate matters by giving engineering advice.

There was considerable discussion, considering various aspects of the problem, but by far the most interesting was that of D. W. A. Evans, Health Commissioner of Chicago, in regard to the relation of pure air to public health. While the city has wisely spent some $50,000,000 in measures for reducing its death rate from typhoid fever (which is now only about 10 per 100,000), it has done little to reduce the death rate from "foul air diseases," although this has always been very much higher than the typhoid-fever rate, and in fact represents 33% of the total death rate. Black smoke is only one form of pollution from coal combustion, and the gases are equally dangerous and objectionable. In one case, where an office building succeeded in having the smoke from a neighboring chimney eliminated, the products of combustion still made the conditions in some of the offices almost intolerable. In London, the aim is now to eliminate not merely smoke, but the noxious products of coal combustion. It has been argued that smoke in the atmosphere is actually beneficial to health, but investigation and statistics support the reasonable and commonsense view that dirt in the air is no more desirable than dirt in water or food.

Mr. A. Bement suggested the organization of a national smoke abatement commission. He also considered that a more energetic prosecution of owners of offending chimneys, together with heavy penalties or fines, would hasten the solution of the problem. On the other hand, Mr. Harrington thought that little real good would be effected by such a policy, but that there should be an energetic policy of education as to the evils of smoke and the means of preventing it without incurring undue expense.

After the recent wholesale demands of the daily press for the electrification of railways as a means of solving the smoke problem, it was interesting to note that Mr. Bird's paper mentioned locomotives only incidentally and made no reference at all to electrification. As shown in Mr. Seley's paper before the Western Railway Club (noted above), the locomotives form but a small percentage of the smoke-producing stacks.

WESTERN RAILWAY CLUB.—At the regular meeting held at the Auditorium Hotel, Chicago, on Nov. 16, a paper on "The Responsibilities and Duties of Railway Officials in the Transportation of Dangerous Articles" was read by Col. W. B. Dunn, Chief Inspector of the Bureau for the Safe Transportation of Explosives and Other Dangerous Articles. His purpose was to call attention to the dangers incident to this class of railway business and to the rules and methods provided for reducing the danger to a minimum, as it appears that there is frequently an indifference to these rules on the part of railway officials. When disasters occur, the tendency is to place the blame upon some man whose ignorance or carelessness is in immediate evidence, whereas it may be that this blame more justly attaches to other men (who perhaps have never seen or handled the particular shipment) whose errors of omission or commission have been prime contributory causes.

At one time, explosives were handled in much the same way as general freight, and with the increase in traffic came an increasing list of disastrous explosions. In 1905, the American Railway Association authorized the appointment of a committee to draft regulations governing the handling and transportation of explosives, but before this committee was appointed an explosion of a carload of dynamite occurred at Harrisburg, Pa., on the Pennsylvania Ry. (May, 1905) which caused the deaths of 23 persons, injured many others, and cost the railway company about $500,000. Immediately after this the Pennsylvania Ry. appointed an inspector of explosives whose duty it was to visit shippers and railway employees, explaining the rules and investigating violations of the rules.

The bureau headed by Col. Dunn proposes regulations for the approval of operating officials, and compiles the results of experience with these regulations for use in improving them. A chemical laboratory is maintained, and the chief inspector of the bureau is called upon frequently for expert opinion and advice.

The paper was illustrated by a number of lantern slides showing the special labels and shipping orders used, the proper way of securing shipments in cars, and showing also the effects of explosions in railway trains.

Following this, a paper on "The Electrification of Chicago Railways" was read by Mr. C. A. Seley, Mechanical Engineer of the Chicago, Rock Island & Pacific Ry. This showed the great difficulties involved in the application of electric traction to the entire system of tracks of all kinds within the city limits, which the city proposes to demand, and showed also that the demand is based largely upon incorrect and irrelevant information. In addition, it was shown that while the demand is made ostensibly in the interests of a "smokeless" city, railway locomotives represent but a small percentage of the sources of smoke. Thus the railway system is a minor offender, but has been selected for the most severe attack and punishment.

Mr. Seley stated that so far every case of railway electrification of any size has been primarily for the benefit of the people in the cars, and these cars operate in tunnels. While it would be feasible to equip Chicago suburban trains for electric traction (though not so easy to operate the electric service), the suburban traffic is only a small proportion of the traffic. The traffic may be classified as follows, in the order of relative importance: (1) Distribution of loaded and empty freight cars to the hundreds of stations, team tracks, deliveries and transfers; (2) handling of freight cars in switching and distributing yards; (3) main line transfer freight trains; (4) division passenger train movement; (5) suburban passenger train movement. Most of the roads make common use of their tracks for passenger, freight and switching movements, and a separation of the tracks for different classes of traffic would necessitate practical reconstruction.

Electric traction is developing rapidly, and some day the way may be clear for its application to the railway system of Chicago, but this is certainly not the case at the present time. Mr. Seley suggested that in view of the complications introduced by the number of railways concerned, there should be appointed a commission consisting of representatives of the railways and the city to consider the problem, and that auxiliary to this commission there should be a board of experts (also representing both parties) to investigate the subject from the mechanical, electrical and transportation standpoints.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—At the regular semi-monthly meeting of the American Society of Civil Engineers held on Nov. 17, a paper entitled "Water-Supply for the Lock Canal at Panama," by Mr. Julio F. Sorzano, M. Am. Soc. C. E., was presented. This paper was published in the "Proceedings" of the American Society of Civil Engineers, October, 1909, p. 1114. In the paper, which we commented upon in our editorial columns in our issue of Nov. 11, Mr. Sorzano seeks to prove that during the three or four months' dry season on the Isthmus the various leakages and necessary uses of the canal and its structures will so reduce the water level of the lake at Gatun that it will be impossible to maintain in the canal the 40-ft. depth which the present design prescribes.

The items which will consume the water are listed by Mr. Sorzano as follows: Surface evaporation; border evaporation; percolation through the bottom and sides of the reservoir; lockage water; normal waste contingent to lockage; water for hydro-electric plants; structure leakage and waste; accident losses; and finally, a general grouping of miscellaneous losses, such as the needs of the local population and industries, the uses of passing vessels, etc. A computation is given in the paper, which proves to the satisfaction of the author that all these leakages and necessary uses will so reduce the water during the dry months that the capacity of the lock canal during that time will be less than 20 round trips a day, and that at no time after the first month of that dry period will a 40-ft. draft be available.

In the ensuing discussion, Mr. C. E. Grunsky, M. Am. Soc. C. E., spoke. As a preface to his remarks, Mr. Grunsky said that it was still a question in his mind whether the lock canal was justified; that the contention of the 1904-05 Board of Engineers that the sea-level canal was the best for the site had never been satisfactorily contradicted, and, although at the present time the Government was undoubtedly committed to a lock canal, still, in his mind, the superiority of that canal over a sea-level canal had never been proved. In regard to Mr. Sorzano's paper, Mr. Grunsky doubted the reliability of the author's assumptions as to loss from marginal fly-off and evaporation, and also bottom percolation. He thought that the marginal losses would be much lower than Mr. Sorzano estimated, as also would be the evaporation, and that the figures assumed for bottom percolation were not justified by any experiments or experience.

Assuming, however, that there would be a certain loss due to evaporation and computing the necessary loss due to leakage and lock usage, Mr. Grunsky figured that 33 lockages per day could be made in the dry season with an 80% intermediate lockage system, to which value four lockages should be added if steam power is used instead of hydro-electric. This is considerably smaller than the official estimate of the future capacity of the canal. Mr. Grunsky thought that in view of the possible losses in the water of the canal, it would be a very good policy for the Isthmian Canal Commission to make investigations now into the proper place for a storage reservoir.

From personal observation, Mr. Grunsky thought that the dam location at Alhajuela on the upper Chagres River was hardly a desirable one, and he preferred the location at Gamboa. However, the Gamboa dam site will be some 40 ft. under water when Lake Gatun is filled after the completion of the canal, so that any studies that are to be made on this site should be made before the canal has reached a very advanced stage of construction.

A written discussion by Lieut.-Col. H. F. Hodges, M. Am. Soc. C. E., of the Isthmian Canal Commission, was also submitted. Lieut.-Col. Hodges answered Mr. Sorzano's paper in detail. In the first place, he said that if in the future the increase in the commerce of the world demanded ships with drafts exceeding the depth of the canal, the money necessary to enlarge the canal to meet these larger ships would be very small compared with the enormous outlay of funds necessary to deepen the harbors of the world. He also said that Mr. Sorzano omitted to credit Lake Gatun with the full amount of water it receives from inflowing streams during the dry season. The Chagres River, for instance, has a greater flow than Mr. Sorzano stated, and this flow continues for some time after the rainfall on the lake proper has commenced to drop. The records of the Commission show that the evaporation coefficient assumed by Mr. Sorzano is too high, also. In figuring the rise and fall of Lake Gatun, it would be well to take account of the amount of water now being absorbed by the vegetation of the country which the lake will cover. This, in the opinion of Lieut.-Col. Hodges, would quite balance the loss of water from the lake by evaporation. The losses from percolation noted by the author were undoubtedly too high, in the light of the investigations now being made on the canal. The losses from lockage were also too high, as no account was taken of the interfeeding of the locks —that is, the supplying one lock from the water of its twin lock. By this method alone there can be saved from 15 to 25% of the water used at the locks. Hydro-electric plant losses were also assumed far too high by the author; only 2,000 HP. are to be used instead of the 6,000 noted in the paper.

Col. Hodges also presented a lengthy argument showing that the water consumption of the locks when using the intermediate gates had been over-estimated. Finally, the losses credited to local needs should never occur, because the Government has ample power to keep any private concerns off of the Canal Zone if they are using water to the detriment of the lockage system.

Taking into account all these mistakes in the original paper, Lieut.-Col. Hodges computed that 48 passages a day could be made through the locks, and that at no time need there be any worry that the depth of the canal will not be great enough to carry at least any boat now in existence. If, however, in the future the increase of commerce demands a larger water supply for the canal, there are several places on the upper Chagres River where storage reservoirs could be easily built.